Addis Ababa University

Addis Ababa Institute of Technology

School of Civil and Environmental Engineering

Identification of Problems on Road Maintenance and Assessment of the Effects of Poor Road Maintenance on Road Function (in the case of Federal Roads of Ethiopia)

By: Ermias Eyob

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Addis Ababa, Ethiopia

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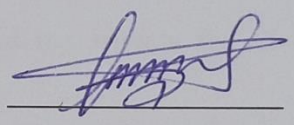
DECLARATION

"I declare that this research report entitled "Identification of Problems on Road Maintenance and Assessment of the Effects of Poor Road Maintenance on Road Function (In the case of Federal Roads of Ethiopia)" is the original work of my own, has not been presented for a degree of any other university and that all sources of material used for the thesis have been duly acknowledged."

Signature: 

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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, even more than one-third of the federal roads are in poor and very poor condition (not safe for driving).

This study focused on the identification of the existing problems of road maintenance and assessment of the overall effects of poor road maintenance on road function. The objectives of the study were achieved through a literature review, desk study, interview and questionnaire survey to identify the most significant problems of road maintenance and the most frequent effects of poor road maintenance on road function. Accordingly, a total of thirty-seven (37) top-ranked problems are acknowledged as the most significant problems on road maintenance under four categories, namely client-related, consultant-related, contractor-related and other problems and a total of eleven (11) top-ranked effects are acknowledged as the most frequently occurring effects of poor road maintenance.

Among them, the study finding indicated that procurement delay, insufficient road condition survey with lack of appropriate project prioritization mechanism and slow decision-making process under client-related problems; staff unavailability on the site, insufficient data collection and condition survey before road maintenance and delay in decision making under consultant-related problems; shortage of equipment, equipment allocation/ management problems and lack of acquiring new and recent technology equipment under contractor-related problems and people in power have a little understanding on the effects of poor road maintenance, road maintenance is politically unattractive and lack of interest by professionals to participate in road maintenance works under other problems are the top-ranked problems on road maintenance. On the other hand, reduce the riding comfort, shorten the service/design life of the roads and increase vehicle operating costs are the top-ranked frequently occurring effects of poor road maintenance on road function. Thus, all the concerning stakeholders are recommended to give all due attention towards the most significant (acknowledged) problems while undertaking any road maintenance to alleviate the problems and minimize their effects.

Key words: Client, Consultant, Contractors, Effects, Problems, Road Maintenance.

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LIST OF ABBREVATIONS

AACRA	Addis Ababa City Roads Authority
AASHTO	American Association of State Highway and Transportation Officials
DDF	District Development Fund
DDG	Deputy Director General
DG	Director General
DOT	Department of Transportation
ERA	Ethiopian Roads Authority
ECWC	Ethiopian Construction Works Corporation
IBC	Input- Based Contracting
MBC	Method-Based Contracting
MOF	Ministry of Finance
MOT	Ministry of Transport
NZTA	New Zealand Transport Agency
PBC	Performance-Based Contracting
PBMC	Performance Based Road Maintenance Contracting
PPP	Public Private Partnership
OPRC	Output and Performance-based Road Contracting
RAM	Road Asset Management
RMB	Ren Min Bi (the official currency in China)
RNSMBD	Road Network and Safety Management Branch Directorate
RNMCD	Road Network Management Coordination Directorate
RII	Relative Importance Index
ROW	Right of Way
RSDP	Road Sector Development Program
RRA	Rural Roads Authority
SANRAL	South African National Road Agency Ltd.
SHAMP	State Highway Asset Management Plan
USA	United States of America
URRAP	Universal Rural Road Access Program

1. INTRODUCTION

1.1 Background

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 will enhance poverty reduction by improving access between regional and rural communities and, ultimately, enhancing socio-economic growth and development (World Highways, 2015).

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. The Department discharges its responsibilities through the ten Road Network and Safety Management Branch Directorates (RNSMBDs) as regulatory/client-side and the ten Road Maintenance District Managers as own-force contractors.

RAM through the ten RNSMBDs and Road Maintenance District Managers strategically located throughout the country carries out road maintenance works on the federal road networks either by using In-House workers through ten (10) Road Maintenance District Managers or by Out-Sourcing the works to private or public contractors. Currently, ERA has executing routine, periodic, emergency, and bridge maintenance works to preserve the road assets by using a budget allocated from the Office of the Road Fund.

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 (Dana and Hitcon Consulting Engineering, 2016, they were 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.

In relation to this, Heggie (2005) stated that 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 Heggie's (2005) 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.

This research is meant to provide insights into the challenges/problems of road maintenance by examining the current practice of ERA. In this research, clear identification of the problems and ranking the identified problems of the road maintenance (by their significance) in the case of Federal Roads of Ethiopia has been carried out. The problems on road maintenance led to poor road maintenance in Ethiopia, which have negative effects on road function; thus, assessment of the effects of poor road maintenance on road function has been studied and a part of this research.

1.2 Statement of the Problem

Roads make a vital contribution to the socio-economic development of one's country. Studies show that adequately maintaining road infrastructure is essential to preserve and enhance social and economic benefits. But a backlog of outstanding road maintenance has caused irreversible deterioration of the road network.

Adequate and proper road maintenance is essential to preserve the road in its originally constructed condition, protect road assets and user safety, and provide efficient and convenient travel along the route. Unfortunately, road maintenance is often neglected or improperly performed resulting in rapid deterioration of the road and eventual failure from both climatic and vehicle use impacts. Due to inadequate and poor road maintenance, rapid deterioration spread across a road network and it results in increasing costs and a major financial impact on the country's economy and many other negative impacts (World Highways, 2015).

As Ethiopia is one of the developing countries, a well-conditioned road network is required to facilitate the socio-economic development of the country. However, most of the federal roads are not in good condition, even more than one-third of the federal roads are in poor and very poor condition (not safe for driving). There are many reasons for not having sustainable and proper road maintenance practices in Ethiopia.

With this in mind, the importance of proper road maintenance needs to be recognized by the concerned stakeholders and decision-makers; including these, there are numerous problems in road maintenance (in the case of Federal Roads of Ethiopia). However, in most instances, these are not recognized and as a result, poor road maintenance has been observed in the federal roads of Ethiopia.

Therefore, this research has identified the most significant problems that hinder proper road maintenance in federal roads of Ethiopia and shown the effects of poor road maintenance on road function.

1.3 Significance of the Research

The significance of this research is to clearly show the root problems in the current federal road maintenance practice of the Ethiopia, and the overall effects of poor road maintenance on road function; thus, it will allow to have common understanding and/or logic upon it and to find counter-measures or to address the problems/challenges encountered in the current road maintenance practice of Ethiopia.

The implementation of sustainable and effective road maintenance requires the identification of the existing problems/challenges of road maintenance. Hence, identifying critical problems can be input towards improving road maintenance activities of the federal roads of Ethiopia.

1.4 Objective

The general objective of this study is to investigate the existing problems/challenges of road maintenance and to show the overall effects of poor road maintenance on road function.

The specific objectives of this study are:

- ✓ To examine the current road maintenance practices of Ethiopian Road Authority/ERA.
- ✓ To identify existing problems of road maintenance and showing their magnitudes in the case of federal roads Ethiopia.
- ✓ To assess the overall effects of poor road maintenance on road function.
- ✓ To forward recommendations that would help to counter the problems observed in road maintenance based on the findings from the study.

1.5 Research Questions

The research questions that this study will attempt to clarify and answer are;

- ✓ What is the current road maintenance practice of ERA?
- ✓ What are the reasons for not having effective and sustainable road maintenance in the case of federal roads Ethiopia?
- ✓ Which problem plays a significant role in poor road maintenance?

- ✓ What are the effects of poor road maintenance on road function?

1.6 Scope and Limitation of the Study

The scope of the research is limited to investigate the existing problems/challenges of road maintenance in the case of federal roads Ethiopia and show the overall effects of poor road maintenance on road function. The study has focused on only ongoing (having the minimum progress of 50% as of October 2020) and recently completed (since 2019) road maintenance projects undertaken by ERA.

Whereas, the major limitations of the research were the following but not limited to;

- ✓ Unavailability of sufficient primary resource due to Covid 19 pandemic.
- ✓ The data for the desk study was collected from ERA and it was hard to find organized data.
- ✓ Late response of respondents in the questionnaire survey.

2. LITERATURE REVIEW

2.1 Introduction

The primary objective of this literature review is to gain insight into the theoretical framework for the study and an understanding of the research objectives. The literature review focuses on the overview of road maintenance and on the identification of problems/challenges for not having sustainable road maintenance by looking into previous studies carried out on the subject areas. It also focuses on the effects of poor road maintenance on road function.

2.2 Function of Roads

Roads are being constructed for the primary purpose of carrying people and goods. Over the years the demands of roads have been expanding. Roads allow people and automobiles to traverse a diverse range of lands so that they can reach their destination without any hindrance. (World Highways, 2015)

Furthermore, Highways (2015) has also stated that the roads make a vital contribution to economic development and growth and bring important social benefits. They are of vital importance in order to make a nation grow and develop. In addition, providing access to employment, social, health and education services makes a road network crucial in fighting against poverty. Roads open up more areas and stimulate economic and social development. For those reasons, road infrastructure is the most important of all public assets.

The transport system is often described as the lifeblood system of modern society. Roads constitute a fundamental part of this system for both passenger and freight transports. The function of the road, from a freight perspective, is manifold. It is used for small shipments over short distances as well as their counterparts. Road freight is most often necessary at the beginning and end of the multimodal transport chain (first/last-mile logistics). Furthermore, road freight is the only mode involved in many door-to-door freight chains, as it is usually the only mode involved (Engström, 2016).

The proper development of the transport road network not only reduces the cost of transportation, both in terms of money and time but also helps in the integration of various regions within the country and the better understanding of neighboring countries at the international level (Aldagheiri, 2009).

The main characteristic of the construction of roads is connecting people from different parts of the county in order to ensure their participation in all aspects of life together with free movement of goods and passengers. County and local roads are of great importance as a part of the road network in the distribution of traffic at a lower level. Modernization in all aspects of life requires modernization and development of transport infrastructure, which leads to a faster and better flow of transport services (Boskovic & Tepsa, 2015).

Roads are a primary method of transportation, used daily all around the world to transport people and cargo. There are different types of roads for different needs, and each plays an important part in general transportation. The importance of road transportation comes from the ease with which they allow people to get from one place to another for a variety of purposes (Tourism Teacher, 2020).

The Tourism Teacher (2020) has also stated that the function of roads as a movement of people would be much more difficult without roads. It is difficult for a nation to grow and develop without roads. They take children to school, they transport produce, they allow for easy movement between different areas which is important in terms of widening culture and more.

2.3 Definition of Road Maintenance

According to Ethiopian Roads Authority (2003), 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).

AASHTO (1987), defined highway maintenance as a program to preserve, repair and restore a system of highways with its elements to its designed or accepted configuration. System elements include travel way surfaces, shoulders, roadsides, drainage facilities, signs, markings, lightening, fixtures, etc.

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

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).

Sally Burningham and Natalya Stankevich (2005) stated that routine maintenance comprises small-scale works conducted regularly, aims "to ensure the daily passability and safety of existing roads in the short-run and to prevent premature deterioration of the roads". 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. For gravel roads, it may include regarding every six months.

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).

2.4.2 Periodic Maintenance

According to Sally Burningham and Natalya Stankevich (2005), periodic maintenance covers activities on a section of road at regular and relatively long intervals, aims "to preserve the structural integrity of the road". These operations tend to be large scale, requiring specialized equipment and skilled personnel. They cost more than routine maintenance works and require specific identification and planning for implementation and often-even design. 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.

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 will be developed (JICA, 2003).

2.4.3 Emergency Maintenance

John (2006) as cited in Biniam (2015) 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.

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 2.1 shown below summarizes the typical activities of each type of maintenance work (JICA, 2003).

Table 2.1 Typical Maintenance Activities

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

Maintenance Type	Activity
Periodic	Re-graveling
	Resealing/surface dressing
	Overlay
	Maintenance of traffic signs and road markings
Emergency	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).

Zietlow (2007) as cited in Biniyam (2015), when roads are in poor condition every $ “saved” in road maintenance will cost: $ 3 to road users in addition to VOCs and $ 2 to the road administration (or the taxpayer) in reconstruction and rehabilitation. Heggie and Vickers: World Bank (1998) as cited in Biniyam (2015); road maintenance reduces the rate of pavement deterioration. It lowers the VOCs on the road by improving the running surface and it keeps the road open continuously. Robinson et al. (1998) as cited in Biniyam (2015) the importance of road maintenance is stated as the following: -

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 (1998), 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 (1998), 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).

As noted in COMCEC Coordination Office (2016) road maintenance is important because poorly maintained roads lead to:

- ✓ Destruction of the value of road assets and its corresponding impact on government accounts and higher costs for road rehabilitation in the future.
- ✓ Higher VOCs, fuel costs, and reduced road safety.

- ✓ Reduced access resulting in poorer healthcare, fewer employment and educational opportunities.

Therefore, focusing on road maintenance will bring widespread benefits by not only preserving current assets, but also lowering future costs for citizens, road users, taxpayers and road owners. This would prevent these assets from depreciating and provided that timely investment is carried out in time. (World Highways, 2015)

2.7 Road Maintenance Practices in Developed Countries

2.7.1 USA

The United States Department of Transportation (DOT) received $74 billion in 2013 for the construction and maintenance of the roads nationwide (USDOT 2013). Every year, the state DOTs spend a significant amount of this budget to maintain their road networks (P. P. Shrestha.P & Shrestha.K, 2014).

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).

According to Shrestha.P & Shrestha.K (2014) DOTs in the United States maintain their roads either by using In-House workers or by Out-Sourcing the works to private contractors. Out-Sourcing uses two types of road maintenance contracting methods, Prescriptive or Method-

Based Contracting (MBC) and Performance-Based Contracting (PBC). Under the In-House method, the state DOTs maintain their road networks using their regular staff and equipment.

State DOTs use in-house staff and equipment to perform road maintenance activities for small-scale projects in terms of budget, quantity, or number of activities. State DOT staff is paid a regular salary, and materials are purchased from suppliers; they work in close coordination with the department authorizing the project (P. Shrestha.P et al., 2017). The In-House method is suitable for activities that require an emergency response and have few maintenance activities. In addition, it is suitable for bridge and tunnel work, shoulder maintenance, landscape works, and litter and debris pick-up. Emergency response activities in the winter season, from October 15 to April 30, are snow removal, anti-icing, and de-icing (P. P. Shrestha.P & Shrestha.K, 2014).

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. Ellevset (2001) as cited in Shrestha et al., (2017), one important benefit of outsourcing when 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.

State DOTs use the MBC method while Out-Sourcing the maintenance works to the contractors. With this method, ‘Lowest-Bid’ is used most often to select the contractors. The

MBC specification specifies to the contractor 'what to do,' 'when to do it,' and 'how to do it'. Generally, the MBC method is selected when the state DOTs lack a skilled workforce and have time constraints. With this method, the payment to the contractor is based on the contractor's bid rate and a measurement of the work completed (P. P. Shrestha.P & Shrestha.K, 2014).

Shrestha.P & Shrestha.K (2014) states that the Hybrid contracting method is a combination of MBC and PBC uses two specifications, to maintain the roads. As this method is a combination of two specifications, some activities are performed according to one specification and others are performed using the second specification. Generally, a hybrid contract is used on large maintenance works.

A study of Zietlow (2004) as cited in Shrestha.P & Shrestha.K (2014) synthesizes the practices of PBC and the traditional contracting method. Traditional contracting, 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 MBC. Further, the author suggested four advantages of PBC over MBC as the following:

- ✓ 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).

According to Mostafa Hassan (2018) the non-toll roads in South Africa are funded directly by tax revenues generated by the national government, but as a result of the insufficient funding from the government, in 1995, the toll road was introduced to support the development and maintenance of roads in South Africa. These are maintained with toll revenues and capital market borrowing. Overall, while toll road conceding is rare in Africa, South Africa in the Sub-Sahara region has conceded the most, which is approximately 0.1%.

Mostafa Hassan (2018) states that SANRAL is very close to achieving its aim and was categorized as a top performer alongside with Namibia. Yet, South Africa has a road maintenance funding backlog of approximately 80-149 billion Rand. Apart from funding, SANRAL is getting it right with the strategies of maintenance such as; routine, periodic and special (urgent) maintenance which are in place. Only the municipal roads are not well managed, this results from poor data collection (only 4%) of the present conditions available, and thus municipality coordination and responsibility are confused. Nonetheless, the manner of contracting maintenance work, which is performance based, has greatly contributed to the success achieved in South Africa.

Nichols Consulting Engineers (2013) as cited in Temesgen (2016), road condition survey is performed by SANRAL‟s automated road survey vehicles road Survey Vehicle (Truck) which able to measure road surface deflections, 3D surfaces cracks (>0.75mm) and 3D right of way laser point clouds at 80 km/h, which are equipped with laser, video and computer-based

technologies. The pavement management system has been used effectively to justify increased funding for road maintenance and preservation. Simple but clear presentations of network analyses and maintenance needs have been made to local and national politicians.

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 Asian Development Bank (2012), the 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.

Whereas, at the provincial level, provincial highway bureaus have the discretion to manage routine and minor road maintenance work in their jurisdictional areas. The necessary funding is directly appropriated to each municipal financial bureau from provincial financial departments. Provincial highway bureaus are responsible for supervising road maintenance work. They issue performance targets, establish evaluation criteria, and conduct annual inspections of maintenance work. For intermediate and major maintenance work, each municipal highway bureau has the discretion to submit annual plans to provincial highway bureaus for examination and approval. Once plans are approved by provincial highway bureaus, corresponding maintenance plans and budgets are issued to municipal highway bureaus for implementation. Plan implementation is monitored and checked by provincial highway bureaus. Provincial transport departments are responsible for developing and issuing rural road maintenance plans and monitoring rural road maintenance work.

China published the Plan of Reform of Management and Maintenance System for Rural Road in 2005, which marked a new era of rural road maintenance. This plan, together with the

Interim Management Methods of Rural Road Maintenance (2008) and Technical Regulations of Road Maintenance (2010) regulate the liable subjects and the technical criteria and subsidy distribution of rural road maintenance (Fan, 2011).

Fan (2011) states that to ensure a stable fund flow for rural road maintenance, there were two main financing channels before 2009: road tolls and government revenue. It was regulated that road tolls (including vehicle road tolls, tractor road tolls, and motorcycle road tolls) were to be mainly used for road maintenance. After deducting the cost of toll collection and traffic policing, no less than 80 percent of the tolls collected would be used for road maintenance. The road tolls collected by local governments must be used for road maintenance, which was a priority over road construction. The provincial transport departments were responsible for distributing vehicle tolls to rural road maintenance. The municipal and county transport departments were required to allocate all the tractor and motorcycle tolls to rural road maintenance.

The direct funding from government revenue was arranged by governments at different levels. Except funds from municipal and county revenue and collected tractor and motorcycle tolls, all the other funds were managed by provincial governments and were appropriated to county government institutions.

However, in 2009, the central government abolished road tolling on government-funded roads and a fuel tax was introduced. The government finance departments also collect fuel taxes. The gasoline consumption tax has been increased from 0.2 RMB/liter to 1 RMB/ liter and the diesel consumption tax has been increased from 0.1 RMB/liter to 0.8 RMB/liter.

According to Fan (2011), nowadays, funding for rural road maintenance in China comes from six different sources:

I. Local government revenues, which cover provincial, municipal and county-level revenues and are usually used for routine maintenance.
II. Central government revenue, which provides funds for rural road maintenance, particularly for poorer regions.

III. Road tolls from tractors and motorbikes, a part of which are used for rural road maintenance.
IV. Vehicle road tolls of provincial transport division, which are used for medium and heavy maintenance work and reconstruction projects. The funding criteria are no less than 7000 RMB/km per year for county roads, 3500 RMB/km per year for township roads, 1000 RMB/km per year for village roads.
V. Donations from benefited enterprises and individuals
VI. Money raised by farmers through "one case, one meeting"

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

- ✓ 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

The New Zealand Transport Agency (NZTA) is among the best organized and managed road agencies in the world. New Zealand has a widespread road infrastructure, consisting of state

highways, local (rural) and urban roads. State highways are administered by NZTA. The state highway network provides a strategic road link between districts and regions. A state highway is a road that is declared to be a state highway under section 11 of the National Roads Act 1953 (section 60 of the Government Road Powers Act 1989) or section 103 of the Land Transport Management Act 2003. Currently, their length is around 11,000 km (COMCEC Coordination Office, 2016).

According to COMCEC Coordination Office (2016) road network management aims at enabling efficient movement of people and goods across New Zealand's infrastructure. NZTA does this through the management of its assets and the ways people use the network. NZTA uses a strategic and systematic process of operating, maintaining, upgrading and expanding physical assets to manage the effectiveness of transportation assets throughout their lifecycle. This integrated approach leads to the publication of the State Highway Asset Management Plan (SHAMP) which covers all infrastructure assets that together form the state highway network, including road carriageways, bridges and structures, drainage features, traffic facilities, lighting, Intelligent Transport System assets, landscaping and miscellaneous assets within the road reserve.

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. Likewise, the Road Information Management and Support System (RIMSS). They 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)

Like the USA, before undertaking any maintenance activities, proper road inventory and condition surveys are undertaken in New Zealand to select the appropriate treatment type. FHWA (2005) as cited in Yetnayet (2017) data are collected both visually on 10 percent of the

road network each year and across the whole national network with a high-speed data-collection vehicle called a Sideways-Force Coefficient Routine Investigation Machine (SCRIM). This vehicle collects data at 10-m intervals for skid resistance, rutting, roughness, and texture and videotapes the network. These data are measured in both wheel paths to allow comparison across the entire paved surface. Pavement strength data are collected with FWD at 200 m. These data are collected via private contractors on highways with over 2,000 average annual daily traffic (AADT), and cover about 10,000 lane kilometers each year (or once every 3 years). To calibrate this data-collection activity, Transit New Zealand uses 52 calibration sites throughout the country. A walking profilometer is used to validate IRI measurements.

Regarding road maintenance methods in New Zealand, part of the work is outsourced to private sector suppliers on a competitive basis to ensure that the investments achieve the best value for money. Those consultants and contractors are mostly used in maintaining the network. In New Zealand too, Public-Private Partnerships (PPPs) are used for the funding of new projects (COMCEC Coordination Office, 2016).

NZTA maintains close working relationships with:

- ✓ Transport operators and the general public, who use the network,
- ✓ Transport committees, regional councils and territorial local authorities, which are responsible for implementing transport projects and other activities funded through NLTP,
- ✓ Suppliers, including contractors and consultants,
- ✓ NZ Police which provide a range of road policing services, and
- ✓ The Ministry of Transport which is responsible for developing the strategic transport policy and monitoring the performance of state entities in the sector.

As mentioned in COMCEC Coordination Office (2016) to obtain the best value for money, all state highway improvement, maintenance and operations works are outsourced. Around 200 contracts are tendered on a competitive basis yearly. NZTA uses a range of delivery models, which are based on international best practices.

In New Zealand all the physical works and professional services are supplied under contract using Alliance, Performance Specified Maintenance Contract, Hybrid or Measure and Value contract forms. About one-third of state highway maintenance in New Zealand is outsourced through PBSMC wherein both network management and physical works are contracted for a lump sum price. These long-term contracts, usually 10 years in duration, define outcomes in terms of the levels of service and performance measures (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).

Whelan and McCurdy (1996) as cited in Naazie. et al., (2018) 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.

Levik (2016) strongly stated that in spite of increased awareness of the impact of neglecting road maintenance, there is still a reluctance to prioritize maintenance. The reason for this can be described in the following terms:

- ✓ Different Ministries have to struggle with the same type of questions and policies in their own field, e.g., education, health, housing, elderly care, environment, etc.
- ✓ The Road Authorities have not been able to develop reasonable tools to predict the changes in maintenance standards resulting from different levels of grants.
- ✓ The Road Authorities have not been able to document the consequences of what will happen to the roads when there is a lack of funds.
- ✓ Undermining road maintenance works: - Working with maintenance is still looked upon even today by professional people as a low-status occupation. To engineers, maintenance is not glamorous. They are trained to design and to construct and do not consider maintenance as their mission in life.
- ✓ Maintenance has not been looked upon by universities as an intellectual subject and little funds have been devoted to this area (Levik, 2016). This is also true in Ethiopia; based on the informal question to BSc degree graduates in civil engineering, almost all the universities have not included road maintenance in their curriculum for civil engineering at the BSc degree level (only a few universities have included it in elective courses). Observing this fact, Yetnayet (2017) has recommended that to get competent professionals in Road Asset Management, universities have to provide intensive courses in Asset management by establishing appropriate departments at the graduate and undergraduate level and share experience from other countries and professional associations how to develop this competency.

Availability of physical resources to undertake certain treatments (manpower, equipment and materials) may impose further constraints (Chan et al. 2001). Davis and Van Dine (1998) included in their maintenance optimization model minimum and maximum amounts of each

treatment that can be deployed in each year. The minimums were 'introduced to avoid a solution that calls for extreme shifts in pavement material production from year to year' (Harvey, 2012).

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;
- ✓ 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).

Yetnayet (2017) 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.

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, lack of clearly defined responsibilities, inefficient management structures, and weak management systems. These cause road agencies to be inefficient (Heggie I. G., 2004).

2.8.1 Institutional Framework:

The Heggie I. G., (2004) study in Sub-Saharan Africa (SSA) revealed that part of the reason for poor road maintenance policies is attributable to the institutional framework within which roads are managed. They are not managed as part of the market economy and this biases managerial incentives. There is no clear price for roads, road expenditures are financed from general tax revenues, and the road agency is not subjected to any rigorous market discipline. Roads are managed like a social service. Road users pay taxes, user charges and the proceeds are nearly always treated as general tax revenues. Instead of being financed through user charges, roads in SSA are financed through budget allocations determined as part of the annual budgetary process. These allocations bear little relationship to underlying needs (i.e., to the cost-effectiveness of road expenditures at the margin) or to road users' willingness to pay. Revenues and expenditures are completely delinked. There is no hard budget constraint (i.e., there is no direct link between revenues and expenditures), no price to ration demand (do we want more or less of particular road services?), and expenditures are not subjected to the rigorous tests of the market place (how much road spending can we afford?).

The above framework biases managerial incentives and affects the way roads are managed. First, since road users do not directly pay for roads, they are not forced to choose whether and how to make the journey or to hold the road agency accountable for the way it spends its budget. Second, the absence of a firm link between revenues and expenditures encourages road users to demand more road spending because it is financed from general tax revenues and does not affect payments for road use. Third, without a hard budget constraint and pressure from road users, the road agency does not have to manage resources efficiently. The government rarely provides clear objectives (in practice, road agencies are often required to employ too much labor and to build roads which are uneconomic), managers face few incentives to cut costs (major cost reductions may simply lead to reduced budget allocations), there are few sanctions, staff cannot easily be disciplined, and managers are rarely penalized for poor performance.

According to Gunter J. Zietlow (2014) the institution system of road maintenance has been identified to be at the root of the problem. The rules and regulations of the public administrative system do not allow for an effective and efficient management of road maintenance.

2.8.2 Human Resource Constraints:

The study of Heggie I, (1995) revealed that most road agencies suffer from an acute shortage of skills, or have an abundance of staff with the wrong skills. Human resource development is an urgent priority. However, without adequate terms and conditions of employment, the standard prescriptions of training and technical assistance simply don't work. The staff shows little interest in training geared to their task in the road agency when they spend half their time daylighting for another employer. Technical assistance cannot transfer skills when staff are demoralized, or day-lighting.

Further study by Heggie I. G., (2004) revealed that human resource constraints are the single most important issue facing most road agencies. Sub-Saharan Africa (SSA) suffers from an acute shortage of technically qualified staff and still employs far too many unskilled workers.

2.8.3 Inadequate Financing Arrangements:

According to Sally Burningham and Natalya Stankevich (2005), good maintenance requires a steady and reliable flow of funds. There are several reasons why this often fails to materialize. Those responsible for allocating the budget may have little understanding of the economic and social importance of maintenance; they may have allowed the budget process to become politicized, favoring construction, which is more visible and popular, over maintenance; or they may believe that fiscal constraints justify deferring maintenance, which only raises future costs.

Heggie I. G., (2004) has also stated that financing arrangements for road maintenance are crucially important. Without an adequate and stable flow of funds, road maintenance policies will not be sustainable. That is an important part of the problem in Africa. Road maintenance expenditures in almost all countries are well below the levels needed to keep the road network in stable long-term condition. In most countries, they are less than half the estimated

requirements and, in some, less than a third. Furthermore, the flow of funds is inconsistent. Budget allocations are often cut at short notice in response to difficult fiscal conditions, funds are rarely released on time, and actual expenditures are often well below agreed budget allocations. As a result, roads throughout the region continue to deteriorate, rural roads regularly become impassable for traffic flow during the rainy season, and the large backlog of road rehabilitation continues to increase.

Heggie I. G., (2004) has tipped the main reason why road maintenance is underfunded in SSA, which is the road users pay is very little for the use of the road network. They pay the usual import duties, excise taxes and sales taxes, but so does everyone else. Road user charges in the form of vehicle license fees, a specific surcharge added to the price of fuel (the fuel levy), and international transit fees rarely cover more than 50 percent of expenditures on maintenance and, in some countries, barely cover 25 percent. Most road expenditures are still financed from general tax revenues and donor-financed loans and grants. This is not necessary. Roads can be commercialized, put on a fee-for-service basis, and treated like any other public enterprise.

An added complication is that funds for road maintenance are allocated as part of the annual budgetary process. Under this arrangement, each ministry must compete for funds during the annual budget negotiations and at least in theory, funds are allocated to finance those expenditures with the highest economic return. However, if that were true, road maintenance would not be underfunded.

Another reason why road maintenance is underfunded in SSA is that some countries still spend too much on new investments (mainly upgrading existing roads and construction of feeder roads). One of the reasons for preferring construction over maintenance is that maintenance is financed under the recurrent budget, while investment is financed under the development budget. Since donors are willing to support the development budget, development funds are less constrained than recurrent funds, which are mainly financed from domestic revenue sources. However, a more important reason for favoring new construction is that contracts tend to be larger (hence offering greater opportunities for gratification payments) and politically more visible and glamorous (Heggie I. G., 2004).

The prevailing financial system of road maintenance has been clearly identified to be at the root of the problem. In most of the SSA countries, an adequate flow of funds cannot be secured by the general budgeting financing procedure (Gunter J. Zietlow, 2014).

According to Gunter J. Zietlow (2014), inadequate maintenance is attributable to any of the following reasons:

- ✓ Money is not allocated (insufficient amounts).
- ✓ Money is allocated but not spent.
- ✓ Money is not spent efficiently.
- ✓ Money is not spent effectively.

Addressing only the first cause (i.e., allocating more money) will not be enough to solve the road maintenance problem; it has not sufficed in the past.

The study by Shrestha.P et al. (2017) revealed that the annual maintenance costs represent a small proportion of the cost of new construction and rehabilitation costs; 2-3% for a paved road, and 5-6% for an unpaved rural road. It is unfortunate that despite the rather clear-cut case for investing in preventive maintenance, the amounts spent on maintenance activities remain low in most middle- and low-income countries.

2.8.4 Lack of Clear Responsibilities

A lack of clearly defined responsibilities adds to the above problems. It is often unclear which agency is responsible for managing different parts of the road network, controlling overloading, managing urban traffic, intervening to improve road safety, or intervening to reduce the adverse environmental impacts associated with road traffic (Heggie I. G., 2004).

Heggie I. G., (2004) states that responsibility for roads is regularly spread among half a dozen central government ministries and a whole range of local government agencies. The fragmentation of responsibility, together with the separation of responsibility for construction from that of maintenance, leads to confusion, duplication and a lack of coherent management policies.

In addition, individual road agencies rarely have clearly defined responsibilities. For example, it is often unclear whether trunk roads in urban areas are under the responsibility of the main road agency or the urban municipality. In the latter case, it may also be unclear which agency is meant to pay for the maintenance of these roads.

Heggie I. G., (2004) further states that most road agencies in SSA are likewise unclear about what their responsibilities are regarding axle-weight enforcement (this usually being left to the police). Should they actively intervene to manage urban traffic (and enforce parking and other traffic regulations)? Should they willingly accept civil liability for accidents caused by defective design and maintenance policies? Should they seek compensation from third parties for damage done to road infrastructure (usually by road accidents)? Do they have a responsibility to identify and mitigate the environmental impacts associated with roads and road traffic? Although many of these problems are aggravated by a shortage of technical staff and underdeveloped legal and administrative systems, the core problem is the lack of clearly defined responsibilities. Which ministry is responsible and which agency has been assigned for that responsibility?

2.8.5 Ineffective Management Structures:

According to Heggie I. G., (2004), these problems are worsened by the curious management structures under which most roads are managed (they are not really managed, but administered). At the central government level of SSA, the main road network is usually managed in one of three ways. It is either managed:

- ✓ as part of a combined Ministry of Works, Transport and Communications (Uganda, Botswana and Tanzania);
- ✓ as part of a more narrowly focused Ministry of Works or Transport (Madagascar, Sierra Leone, Rwanda, Zambia and Zimbabwe); or
- ✓ under a sharply focused Ministry of Roads and Highways (Ghana).

Local government roads may either be handled directly through a central road agency (Sierra Leone) or through a separate department forming part of a central road ministry (Ghana) or

through a ministry of local government, which usually delegates most day-to-day operations to the local authorities themselves.

2.8.6 Weak Management Systems:

According to Heggie I. G., (2004), there is a lack of effective management information systems. Many attempts have been made to introduce such systems, but with little success and many failures have been recorded as soon as the consultants who have installed the system left. A recent review has shown that a mere 10 percent of countries in Africa compile basic traffic count and road inventory data, while data on pavement condition, pavement strength, and surface roughness are almost non-existent. No more than 10 percent of African countries have functioning routine-maintenance management systems and pavement management systems to determine network-wide maintenance priorities. The remaining countries have neither the data nor the mechanisms and staff needed for the system analysis. One cannot manage a large road network efficiently without some form of management information system.

According to Temesgen (2016), the greatest challenge for road rehabilitation and maintenance in Addis Ababa City Roads Authority (AACRA) is the absence of a well-established pavement management system. A pavement management system (PMS) is a set of tools or methods that assist decision-makers in finding optimum strategies for providing, evaluating, and maintaining pavements in a serviceable condition over a given period of time.

2.8.7 Inefficient Work Methods:

According to Heggie I. G., (2004), all the mentioned problems lead in the same direction: toward road agencies that do not operate efficiently. Few road agencies in Africa manage resources aggressively enough to achieve maximum value for money. Instead, they deliver poor-quality services based on their (usually inadequate) annual budget allocations. This is evidently exhibited in the undue emphasis on force account work, inefficient operation of government plant pools, and lack of interest in labor-based work methods. These are characteristics of agencies that face no market discipline and have poorly motivated managers who are not held responsible for results.

Heggie I. G., (2004) further argues that inefficient government plant pools are another indication of a lack of market discipline. Most road agencies own millions of dollars' worth of heavy plant and equipment, most of it procured under World Bank loans or furnished on a grant basis by well-meaning bilateral donors. Even a relatively small road agency may own plant and equipment worth $50 million or more. Utilization rates for this equipment rarely exceed 20 to 30 percent, compared with 80 to 90 percent in the private sector, and the economic losses associated with these low utilization rates can amount to over $23 million per year. The superficial reasons for such low utilization rates include lack of standardization, poor management systems, shortages of fuel and spare parts (or shortage of foreign exchange to purchase them), and shortage of trained equipment operators and mechanics (mainly due to poor terms and conditions of employment). However, the real reasons are related to lack of a stable workload (i.e., inadequate road maintenance allocations and an erratic flow of funds), lack of transparent management systems (i.e., costing systems which clearly spell out the costs of low utilization levels) and lack of managerial accountability. Unfortunately, no one knows or no one cares that equipment is underutilized in most of the SSA countries and management is under no direct pressure to find the cheapest and most effective way of getting the work done.

Road agencies in SSA are unlikely to operate efficiently until they are faced with some form of competition or a competition stand-in (i.e. until they are subjected to some form of market discipline). Competition is the primary and the most important factor which motivates managers to cut waste, improve operational performance and allocate resources efficiently.

2.8.8 Road Maintenance is Politically Unattractive

New road construction and road rehabilitation are more "visible" and produce greater political prestige over maintenance. In addition, the lack of maintenance culture and little understanding of the economic consequences of poor maintenance even by those in charge of roads make it even more difficult to raise sufficient and stable maintenance funds. Only very few countries in the world, such as Japan and some European countries have proven to be able to assign sufficient resources to road maintenance on a sustained basis. These are somewhat exceptions

to the rule and cannot be taken as examples for the functioning of financing road maintenance through general taxes (Oronje et al., 2014).

According to Levik, K. (2016), in most countries it is believed to be a political benefit to be in favor of investing money in building new roads instead of maintaining the existing roads. However, road maintenance does not have the same status or does not give the same opportunity to stakeholders or decision-makers to present themselves to the public. Road maintenance has been neglected in the past. This problem is not only limited to the situation with roads. Apparently, people in power think that prioritising new constructions, new buildings or whatever, will result in political benefit and increased attention from the media center and public, especially from the voters.

According to Yetnayet, B. (2017) Lack of political awareness regarding asset management system practice has been costing countries enormously. Since delays in executing maintenance generally lead to increased severity of deficiencies (i.e., to poor or very poor conditions) and can eventually lead to a need for complete pavement rehabilitation or reconstruction in later years.

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).

John Clifton, et al. (2016) as cited in Hana (2017) it is no wonder that proper maintenance action has the capability to extend the service life of infrastructures. However, if such maintenance neglect continues, it will not only reduce service levels and accessibility but also hugely increase the whole life costing of the transport infrastructure. Thus benefits, satisfaction, returns or progress towards stated objectives to be acquired through the work of maintenance could not be achieved.

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).

According to Oronje et al., (2014) road transport carries 80 to 90 percent of the region's passenger and freight transport and provides the only form of access to most rural communities. To handle this traffic, African countries expanded their road networks considerably during the 1960s and 1970s and also built new roads to open up more land for development. By the end of the 1980s, there was therefore nearly two million km of roads in Sub-Saharan Africa. These roads are some of the region's largest assets, with replacement costs amounting to nearly $150 billion. In terms of assets, employment and turnover, these roads are truly big business.

In spite of their vital importance, 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.

According to Gunter J. Zietlow (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.

As noted by Gunter J. Zietlow (2014) the wide-ranging road networks of Latin America and the Caribbean, valued at over 350 billion US$, show alarming signs of neglect and decay. More than 16 billion US $ is being wasted annually due to the absence of adequate road maintenance. Individual countries in the region are losing between 1% and 3% of their annual Gross National Product (GNP) due to an unnecessary increase in vehicle operating costs and loss of road asset value alone. This shocking situation is not only true for Latin American countries but can be found in other developing countries and some developed nations as well.

Road infrastructure shortcomings have manifested themselves in the form of high VOCs and rampant potholes, leading to a decline in road safety and a deterioration of service levels for those who use roads to deliver goods or connect to international markets (Mbara, T.C., M. Nyarirangwe, 2010).

Central Bank of Nigeria (2003) as cited in Oronje et al., (2014), bad roads hinder the movement of commodities and services from producers to consumers and farm produce from rural areas to urban centers. Bad roads also lead to loss of person-hours, with far-reaching consequences on motor vehicle maintenance costs, as well as the emotional and physical health of citizens. Similarly, Nyangaga (2007) points out that a poor road network increases the cost of farm inputs, production and access to markets, which in turn, makes the cost of living unbearable for low-income-earners in a country. Bad roads also constrain access to essential services such as healthcare, education and emergency responses in the event of disasters.

Studies showed that there is a strong correlation between the road surface condition (such as rutting, roughness, smoothness, potholes) and the VOC. So, leaving the surface of the road

without appropriate treatments will lead to a substantial increase in the VOCs and the economic investigation into road maintenance indicates that the implementation of maintenance programs leads to high rates of investment profit. Infrastructure systems deteriorate over time due to external factors such as climate, traffic and aging. Generally, the older the pavement is, the more rapidly it deteriorates. It has been claimed that road deterioration is affected by a combination of factors including, the original design, material types, traffic volume and its axle load characteristics, environmental conditions, age of pavement, and the maintenance policy implemented. Application of preventative maintenance in the first 15 years of pavement life (before the pavement condition deteriorates to a fair condition), will cost less and also extend the life of the road (Jamaa Salih, Francis Edum-Fotwe, 2016).

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).

As noted by COMCEC Coordination Office (2016) the effects of poor maintenance of rural roads lead to serious effects in terms of longer travel times and reduced access. When a large portion of the population are living in rural areas, rural roads become a very important part of the road network in terms of providing access and helping to reach development goals.

According to COMCEC Coordination Office (2016) poor maintenance practices impose the following costs on national economies:

- ✓ Destruction of the value of road assets and its corresponding impact on government accounts and higher costs for road rehabilitation in the future
- ✓ Higher vehicle operating costs, fuel costs, and reduced road safety

- ✓ Reduced access resulting in poorer healthcare and fewer employment and educational opportunities

In addition to these, as noted in Jamaa Salih, Francis Edum-Fotwe (2016) 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:

- ✓ ***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.
- ✓ ***Environmental impact:*** Changes in CO2 emissions are directly related to the above-mentioned impacts.

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).

Heggie I. G., (2004) suggests that 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. They 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.

According to Gunter J. Zietlow (2014), 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.

Unfortunately, this system is not readily available yet and will not be implemented on a comprehensive scale in most developing countries in the near future. For the time being, a shadow toll system is recommended and can be implemented, which mainly uses the consumption of motor fuels on roads as a "service meter" and reflects the usage of roads fairly well. This implies a service charge or road maintenance tariff to be levied and collected together with the sale of motor fuels. The only disadvantage of charging this tariff together with the sale of motor fuels is psychological, as most people consider anything charged together with motor fuels as "another tax" to finance general government expenses and not necessarily the provision of road maintenance services. Therefore, it is extremely important to identify and clearly mark this charge as a road maintenance tariff and to collect the receipts into a separate fund, independent of any government, departmental or municipal funds and make sure that the proceeds are used for road maintenance only.

On the other hand, as noted in Biniyam, R. (2015) Performance-Based Road Maintenance Contracting (PBMC) is a new concept designed to resolve the problems related to traditional methods of contracting and has significant potential to improve the maintenance and management of road infrastructure. PBMC reflects a long-term trend in changing the focus of upper management and maintenance managers to outcomes, especially those that are customer-oriented.

2.11 Summary of Literature Review

In the literature part of the research, the basic concepts on road maintenance have been presented in a detailed manner. Some of the points like definition, types, process and importance of road maintenance were reviewed in detail, which are believed to be an essential point for the discussion of the main focusing areas of this research.

To address the first objective of this research (examining the current road maintenance practices of ERA) reviewing the international practices in road maintenance specially the

developed countries have found necessary as it helps to open the eyes to see the gaps or problems of road maintenance in Ethiopia.

Accordingly, the practices of four developed countries from different continents have been reviewed. From their practices, it is clearly seen that the countries have emphasized on effective and sustainable road maintenance through the appropriate and innovative methods in each process of road maintenance. From the initial, they are performing proper road inventory and condition surveys through automated equipment to select the appropriate treatment types for their road network. They are using modern road maintenance contracting methods like PBMC considering its benefits and sufficiently funding the road maintenance from different sources like a toll road system.

Majorly, the problems of road maintenance were exhaustively reviewed from different literatures. In this regard, which is the major part of this research, very limited literatures are obtained from different sources. One important literature (World Bank Technical Paper) written by Heggie, IG (2004) has shown the general problems of ineffective and unsustainable road maintenance policies in Sub-Saharan Africa (SSA). However, the problems shown on this paper are too general and do not reflect all the problems observed in the case of Ethiopia. Even though a few literatures (thesis done in Addis Ababa Institute of Technology) are obtained from Ethiopia in relation to road maintenance, they did not fully address the mentioned topic. These were the main identified gaps in the literature review and sufficiently covered in this research as per the methodology shown in chapter three.

Finally, the effects of poor road maintenance on road function were also identified from different literatures found worldwide. Even if some of the effects might differ from country to country, time to time; the identified general effects give sufficient insights for the assessment of the overall effects of poor road maintenance on road function in the case of federal roads of Ethiopia.

3. RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This study is conducted on the identification of existing problems/challenges of road maintenance and the effects of poor road maintenance on road function in the case of Federal Roads of Ethiopia. The thesis fundamentally dealt with the ongoing (having the minimum progress of 50% as of October 2020) and recently completed (since 2019) road maintenance projects undertaken by ERA.

This chapter presents the procedures undertaken to achieve the research objectives. The data and information sources, research instruments, sample size and method of analysis are also presented in this chapter. The succeeding section provides a general description of the research design, as well as a justification of the methodology.

3.2 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 RNSMBDs (Road Network and Safety Management Branch Directorates) and RNMCD (Road Network Management Coordination Directorate) under ERA; those have direct involvement in road maintenance projects. The questionnaire was addressed in the closed-form of questionnaire and the respondents were asked to indicate the magnitude/extent of problems in road maintenance and the frequency of effects of poor road maintenance on road function on a 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.

The questionnaires were collected from the participants after a period of one month later. This approach can remove any undue pressure from the respondents and gave them the freedom to fill in the questionnaire as truthfully as possible. The variables in the questionnaire were adapted from the informal discussion made with colleagues and professionals in the sector and researches cited in the literature review.

Finally, based on the finding of the study, especially in relation to financing and budgeting of road maintenance, experts from the Office of Road Fund were interviewed through a semi-structured interview in order to obtain their perceptions on the subject matter. This was designed due to the fact that; the Office of Road Fund is the sole financier of road maintenance in Ethiopia. Semi-structured interview type was selected because it helps to collect reliable qualitative data through the flexible way by keeping the structured questions.

3.3 Source and Types of Data

Data required for this study were collected from both primary and secondary data. The primary data were obtained through a questionnaire directed to project managers from contractors, resident engineers from consultants, counterpart engineers and team leaders from RNSMBDs and RNMCD under ERA; those are currently involving in ongoing and/or recently completed road maintenance projects under ERA. The data collected through this mechanism helps to answer the three major questions of this research, research questions two up to four: such as “what are the reasons for not having effective and sustainable road maintenance? which problem plays a significant role in poor road maintenance? and what are the effects of poor road maintenance on road function?

To answer the first research question, what is the current road maintenance practice of ERA? A desk study was chosen as one of the instruments to assess and obtain actual data about the current road maintenance practice of ERA from secondary data. The secondary data which involves information from a published document such as academics publications, journals, 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.

3.4 Questionnaire Design

The questionnaire has three sections. The first section consists of questions about the general profile or background information of the respondent. The second section is about the problems on road maintenance in the case of Federal Roads of Ethiopia. The third and final section of the questionnaire is about the effects of poor road maintenance on road function. The same questionnaire has been designed for all parties.

Only close-ended questions were asked in the questionnaire. The close-ended questions have the number of choices of possible answers and the respondents selected whatever they feel was most appropriate. The closed-ended questions were selected because they are easier to assess and answer considering how busy the respondents were. The questionnaire is mainly based on a Likert's scale of 5 ordinal measures from 1 to 5 according to the following manner.

I. Problems of Road Maintenance

(1) = Insignificant

(2) = Less Significant

(3) = Averagely Significant

(4) = Significant

(5) = Very Significant

II. Effects of poor road maintenance on road function

(1) = Never

(2) = Rarely

(3) = Occasionally

(4) = Frequently

(5) = Always

3.5 Research Population and Sampling

The population for this study has been identified to be the number of ongoing and recently completed road maintenance projects under ERA. In the case of ongoing road maintenance projects, the projects' progress exceeding 50% during the data collection period (October 2020) have been selected while in the case of recently completed road maintenance projects, the projects with substantially completed since 2019 have been selected. Selecting the ongoing (the progress greater than 50%) and recently completed (since 2019) road maintenance projects as the research population was found appropriate and viable to identify and then to show the magnitudes of the currently existing problems of road maintenance (one of the main objectives of this thesis). These also helped in addressing the first objective of the thesis (examining the current road maintenance practices of ERA).

Accordingly, a total of twenty-one (21) projects were identified; in which nine RNSMBDs at the branch level and RNMCD at the head office level have been administering and/or administered the projects as a client. These projects have been identified by reviewing the documents/archives available in ERA and informal discussions made with Road Network Management Coordination Directorate, Director and Team Leaders. The list of projects, including their respective consultants and contractors, with their progress, which are incorporated in the study population are shown in Appendix-2.

These twenty-one (21) projects were selected, fundamentally to identify the target populations (respondents for the questionnaire) from the three parties, those who have direct involvement in road maintenance projects. Secondly, three projects out of twenty-one (21) projects were selected randomly to overview their practice in relation to the finding of the study (presented in section 4.2: Desk Study in ERA: Road Maintenance Practices of ERA).

As mentioned in the above paragraph (identifying the target populations); seven (7) different consultants have been supervising and/or supervised twenty-one (21) projects under nine (9) packages, out of which two consultants were involved in two different packages at different times. Seventeen (17) different contractors have been maintaining and/or maintained twenty-one (21) projects, out of which two contractors have two different projects and one contractor has three different projects.

Since the total population of the research was small, undergoing a study on all of the population was found safe. Therefore, the questionnaire was distributed in all these twenty-one (21) projects.

The target population for the data collection using the questionnaires consisted of road maintenance administering Directorates from ERA, road maintenance supervision consultants and contractors. Professionals included in this study are those who have direct involvement in road maintenance projects; project managers from contractors, resident engineers from consultants, counterpart engineers and team leaders from RNSMBDs and RNMCD were the selected professionals for the data collection using the questionnaire.

Accordingly, 20 questionnaires for the client, 9 questionnaires for the Consultants and 21 questionnaires for the contractors were distributed (i.e., a total of 50 questionnaires were distributed).

3.6 Interview Design

As mentioned in section 3.3, a semi-structured interview was designed based on the finding of the desk study and the questionnaire to get some qualitative data from the Office of Road Fund. The interview was addressed to key experts in order to deepen the findings of the questionnaire and desk study. The purpose of the interview was to assess the perceptions of key informants/experts from the office of Road Fund on the road maintenance financing system and to check the reliability of the results obtained through a questionnaire.

The interview schedule shown in Appendix 2 consists of four main questions as enumerated from No. 1 to 4, question 1 being inquiry about the interviewees' profile and the remaining

three questions (2-4) focusing on the particular research-related issues. The interview schedule is depicted in Appendix 2.

3.6 Data Analysis

The analysis was done by using Microsoft Excel and the responses assigned to each question by the respondents were entered and the descriptive statistics method was used to analyze the responses in numbers. Descriptive statistics are a method of analysis that provides a general overview of the results and used to analyze the result of questions.

The ranking of the attributes/variables in terms of their criticality as perceived by the respondents was done by the use of the relative importance index (RII). The relative importance index was calculated for each question within the form using the statistical techniques used for ranking elements in the order of their importance as seen or indicated by the participants. The five-point scale ranged from 1(Insignificant) to 5(Very Significant) for each problem on road maintenance and 1(Never) to 5(Always) for each effect of poor road maintenance was adopted and transformed to Relative Importance Index (RII) calculating using the following equation.

$$RII = \frac{\sum_{i=1}^{5} W*Xi}{A*N} \quad \text{[Eq. 3.1]}$$

Where:

W= is the weight given to each factor by the respondents (Ranging from 1 to 5)

X= is the frequency of responses given for each factor

A= is the highest weight (i.e., 5 in this case)

N= is the total number of respondents

Note: The value of the relative importance index had range from 0 to 1, where 1 is extremely important and 0 is unimportant.

Ranks of problems on road maintenance and effects of poor road maintenance on road function as perceived by different parties were tested for correlation. The purpose of a correlation test is to see if there is a difference in ranking between two groups of respondents and to avoid

being deceived by chance of occurrences and impact as ranked by a single part. The tests also help to evaluate whether the consensus of opinions exists among respondents.

The spearman's-rank correlation coefficient for measuring the agreement or difference in ranking between two groups of respondents scoring each factor is applied; because of its advantages of not requiring the assumption of normality and/or homogeneity of variances (Chapman, 2002). It is used for measuring the differences or agreement in ranking between two groups of respondents scoring the various factors (i.e., client versus consultants, clients versus contractors and consultants versus contractors). In this research, it is used to show the degree of agreement between the different parties involved in the survey such as client, consultants and contractors or it is used to measure and compare the relation between the rankings of two parties while ignoring the ranking of the third one.

The Spearman's- rank correlation coefficient (rs) for agreement in ranking between the two parties is given by the following formula (Chapman, 2002).

$$r_s = \{1 - \left[\frac{(6\sum d^2)}{n(n^2-1)}\right]\} \quad \text{Eq. 3.2}$$

Where:

r_s = the Spearman's rank correlation coefficient;

d = difference between ranks given by two parties or respondents for each factor.

n = the number of factors (variables)

Note: The ranking correlation coefficient ranges from -1 to +1. A correlation coefficient of 1 indicates a perfect linear correlation i.e., good or strong correlations (perfect positive relationship or agreement) while -1 indicates negative correlation (perfect negative relationship or disagreement) implying high ranking in one group is associated with low ranking on the other. The correlation coefficient value near to zero indicates little or no correlation.

In conclusion, the two main objectives of this thesis (identifying and then showing the magnitudes of existing problems of road maintenance in the case of federal roads of Ethiopia and assessing the overall effects of poor road maintenance on road function) have been

analyzed through the aforementioned equation (Eq 3.1 & 3.2). The first objective (examining the current road maintenance practices of ERA) has been addressed through the desk study conducted in ERA. The final objective (forwarding the recommendations that would help to counter the problems observed in road maintenance) has been addressed based on the finding of the study.

4. RESULTS AND DISCUSSION

4.1 Introduction

This chapter provides explanations to the issues related to the distribution of the questionnaire, collection of responses and subsequent analysis of the data acquired through the responses of professionals who are working for the client, consultants and contractors and involved in the federal road maintenance projects in Ethiopia. The principal purpose is to rate and rank the identified variables of problems on road maintenance and then to find out the critical problems that are required to be given due attention in future road maintenance projects in Ethiopia. In addition to this, the frequency of occurrence of the identified effects of poor road maintenance on road function has been assessed.

Accordingly, a questionnaire was developed and distributed to the main parties directly involved in the ongoing (with the progress of greater than 50%) and recently completed (since 2019) road maintenance projects, i.e., the client, consultants and contractors; the respondents from the three parties are:

- ✓ From the client (ERA) side: team leaders and counterpart engineer.
- ✓ From the consultants' side: resident engineers.
- ✓ From the contractors' side: project managers.

A total of 50 questionnaires were distributed to respondents, which comprise of the following: 20 for a client (ERA), 9 for consultants, and 21 for contractors; wherein the sample of the questionnaire is attached herewith in the Appendix-1.

Before getting to the analysis and discussion parts as per the responded questionnaires, it is important to present the finding from the desk study which dealt with the current road maintenance practices of ERA.

4.2 Desk Study in ERA: Road Maintenance Practices of ERA

4.2.1 General

A desk study was conducted to assess the current road maintenance practices of ERA. During the desk study, the description of the road network, road condition of federal roads, organization of maintenance, financing of road maintenance and road maintenance contracting method have been studied. In addition to this, the major problems of road maintenance and the effects of poor road maintenance on road function are identified through informal discussions made with ERA officials and professionals in the sector.

The data or information presented in this section has been gathered from the ERA official website, archive (various reports, contract documents and other relevant documents), interviews with Engineers working in the RAM department of ERA.

4.2.2 Description of Road Network

In 1951, when the Ethiopian Roads Authority was established, the total road network amounted to 6,400 km. This network was built mainly during the Italian invasion. By 1997 the road network of a country had grown to 26,550 km, of which 3,708 km were paved (Yetnayet, 2017).

Great achievements have been recorded in developing road networks since the start of RSDP, 1997. ERA road asset database of 2019/20 shows that the total Federal Road network is estimated at about 29,106 km and the Regional Road network is about 35,985km. The road network also includes about 55,000 km of roads under Woreda (URRAP/Community) administrative, 295 km toll roads under Ethiopian Toll Roads Enterprise and about 23,000 km of roads in urban centers.

The total length of the road network in Ethiopia is 143,383 kilometers. These road networks do not include the roads under construction and plan. Federal roads make up about 20% of the total road network in Ethiopia, and most of these roads (60%) are paved roads. Finally, the expressway is quite small; it is only 85 km in length (Addis-Adama Road). However, another 205 km of the expressway is under construction.

The total federal road network of the country at the beginning of the RSDP (1997) was about 15,870 km. Due to the construction of new gravel and asphalt roads during RSDP; the total federal road network has increased to 29,106 km in 2019/20. In general, the federal road network in Ethiopia has been increasing on average by 3.2% between 1997 and 2020 as shown in Table 4.1. This shows that ERA has performing well in increment of road network coverage; hence, as the road network increases the resources and budget for proper road maintenance should increase accordingly. Table 4.1 shows the development of the federal road network in the past ten years.

Table 4.1: Growth of Federal Road Network

Year	Asphalt (Km)	Gravel (Km)	Total (Km)	% Increase
2010/11	7,476	14,373	21,849	
2011/12	8,295	14,136	22,431	2.6%
2012/13	9,875	14,675	24,550	8.6%
2013/14	11,296	14,455	25,751	4.7%
2014/15	12,640	14,220	26,860	4.1%
2015/16	13,551	14,055	27,606	2.7%
2016/17	14,751	13,400	28,151	1.9%
2017/18	15,886	12,813	28,699	1.9%
2018/19	16,172	12,527	28,699	0.0%
2019/20	17,464	11,642	29,106	1.4%

(Source: ERA road asset database, 2019/20)

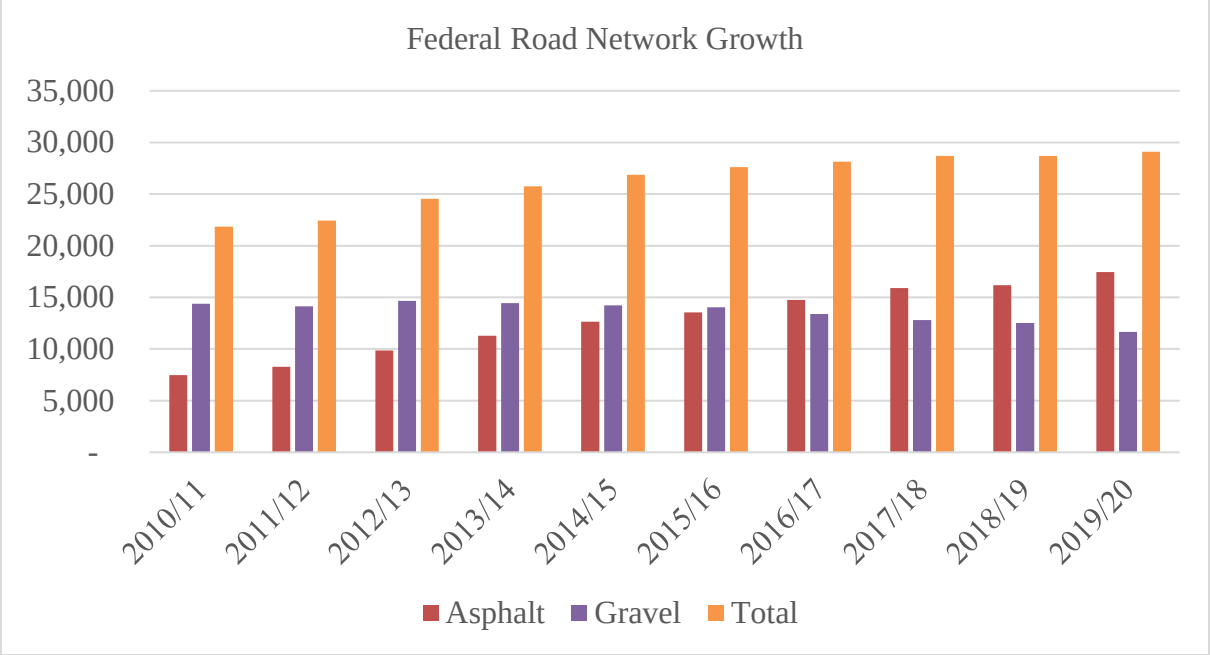

Figure 4.1: Federal Road Network Growth

4.2.3 Road Condition of Federal Roads

Previously, ERA has undertaken the road condition through visual inspection or professional judgment which is subjective and doesn't reflect the actual condition of the Roads.

Considering this gap, ERA hired two consultants (namely Dana and Hitcon) to undertake the detailed condition survey of the roads through automated equipment such as Hawkeye 1000, Hawkeye 2000, FWD, etc. and they came up with a result in the 2016 year, which is the latest information on the road conditions, as shown in Table 4.2.

From Table 4.2 and Figure 4.2, it is observed that most of the federal roads are not in good condition both in the case of paved and unpaved roads. Numerically, about 74% of paved roads and 86% of unpaved roads are not in good condition; according to the consultants' study, about 37% of paved roads and 38% of unpaved roads are in poor and very poor condition (not safe for driving).

This indicates that there are problems in road maintenance in the case of Federal roads of Ethiopia. Based on this general and proved fact, informal discussions were made with ERA

officials and professionals in the sector to identify the problems of road maintenance. Accordingly. several problems were identified and presented under sub-section 4.4.

On the other hand, even if proper road maintenance improves the road condition for the specified period; in some specific road corridors, the improved road condition is serving for a very short period (do not serve for a defined period) and damaged rapidly due to the overloading on the pavement. Overloading on the pavement is a unique problem on the road as a general, which is beyond the road maintenance problem; as it is directly related to the country's axle load rules and regulation in addition to the country's economic condition. Currently, this problem is majorly visible on the Addis Ababa – Djibouti road corridor, as most Ethiopian import-export materials are trucking through this corridor. Hence, special treatment and axle load control should be implemented in such type of particular road. Therefore, overloading on the pavement is not considered as a problem of road maintenance in this study.

Table 4.2: Road condition of Federal Roads as of 2016.

Road Condition Description	**Federal Road Condition by %**	
	Paved	**Unpaved**
Very Good	0%	5%
Good	26%	9%
Fair	37%	48%
Poor	11%	28%
Very Poor	26%	10%

(Source: ERA road asset database, 2019/20)

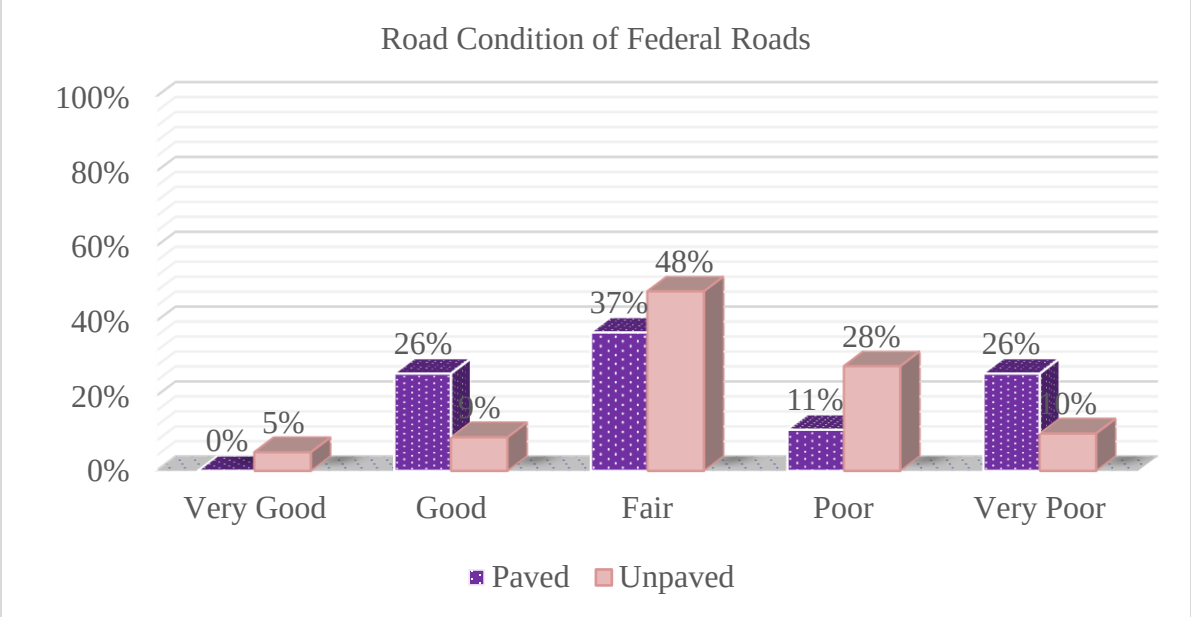

Figure 4.2: Road Condition of Federal Roads as of 2016

4.2.4 Organization of Maintenance

Under the Ministry of Transport, ERA is responsible for the development, operation, construction, and maintenance of the federal road network in Ethiopia. There is a maintenance department under ERA so-called Road Asset Management (RAM) Deputy Director-General, that is responsible for executing the required routine, periodic, and emergency maintenance, as well as the overlay works.

The Ethiopian Roads Authority (ERA) was restructured to sustain and accelerate the quality improvement of the federal road network. A new RAM Department, headed by Deputy Director-General has been set up recently with responsibility for road asset management coordination (Yetnayet, 2017).

The RAM has fourteen directorates and ten district managers that are responsible directly or indirectly for carrying out emergency, routine and periodic maintenance. Out of fourteen directorates, four directorates are located in head office and the remaining ten (10) directorates and ten (10) district managers are strategically located throughout the country (one directorate

and one district manager in one place) to carry out road maintenance works on the federal road network.

In general, RAM DDG is responsible for short- and long-term road network maintenance plans to ensure the mobilization of adequate resources for the maintenance of the network and the provision of roads with the acceptable operating condition for vehicles. The department is responsible to produce effective network maintenance plans using standard road asset management tools such as Pavement Management System (PMS) and Highway Development and Management Model (HDM 4). The Department is also responsible for functional classification and numbering of the road network and for database of the network using PMS and HDM 4 and other appropriate tools (Yetnayet, 2017). To perform the aforementioned responsibilities, the department has discharged its duties to the directorates accordingly.

Road Asset System Management Directorate is responsible for the inventory and condition surveys of the road network and other assets through the formulated systems like PMS, Bridge Management System (BMS), Axle Load Management System (ALMS). The Department is also responsible for short- and long-term road network maintenance plan, database management, functional classification and numbering of the road network. While Road Network Management Coordination Directorate (RNMCD) is responsible for supporting, coordinating, monitoring and evaluating the performance of ten RNSMBDs located throughout the country; in addition, the directorate is responsible to administer some selected road maintenance projects.

Road Maintenance Directorate is responsible for supporting, coordinating, monitoring and evaluating the performance of ten Road Maintenance District Managers located throughout the country. While RNSMBDs are responsible for road network administration, road maintenance projects administration, road safety control, axle load control and right of way (ROW) management under their branch directorate.

Road Maintenance District Managers were previously under Ethiopian Construction Works Corporation (ECWC) and are currently transferred to ERA on November 29, 2019. They are responsible to maintain emergency and routine maintenance of their road networks using their

regular staff and equipment by fixed and agreed rate between them and RNSMBDs. They maintain the roads when the quantity and work orders are given from the respective RNSMBD. Most importantly they perform all emergency maintenance under their district and they are ready and stand-by for it. As Road Maintenance District Managers require different equipment to perform their assignment, one more important directorate was organized at the head office level, the so-called Central Equipment Administration & Maintenance Management Directorate, which is responsible for equipment maintenance, equipment administration, equipment procurement and supply and all insurance-related cases.

As stated above, Road Maintenance District Managers have joined ERA in 2019, this department including its previous organization (ECWC) was under ERA before a decade; however, the organizations had been split at that time and rejoined now. Such type of organizational structure change has its own negative impact on road maintenance. Thus, a poor organizational structure is one of the identified problems of road maintenance.

Figure 4.3 shows the general organizational structure of ERA Road Asset Management, DDG, in the current year (2020).

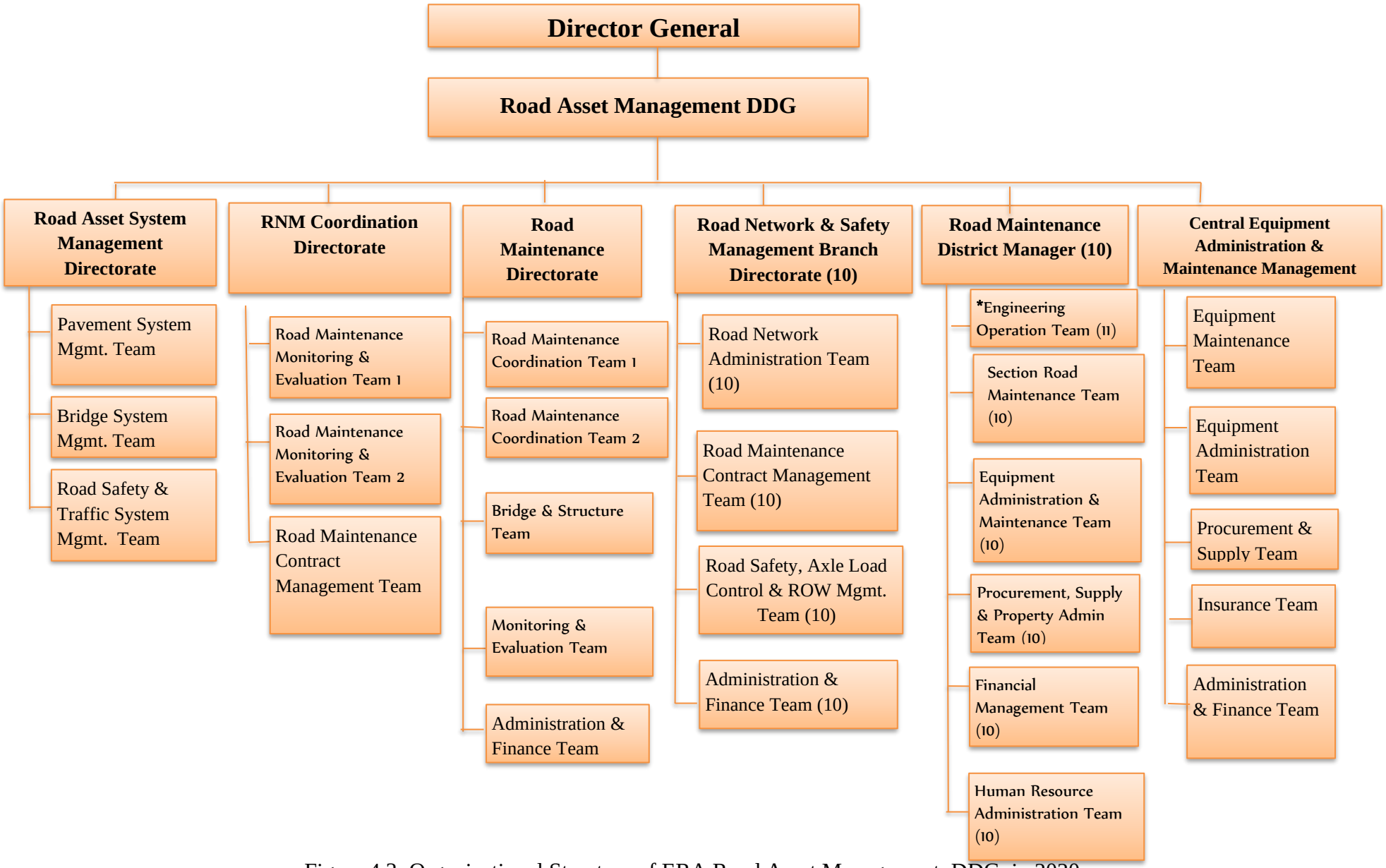

Figure 4.3: Organizational Structure of ERA Road Asset Management, DDG, in 2020

4.2.5 Financing of Road Maintenance

Total transport cost includes the costs of Road construction and maintenance, vehicle-operating cost, and any other external or third-party costs of transport that are associated with society at large and the environment. Road maintenance cost, as part of total transport cost, is one major determining factor for the up keeping of Road asset value of a country. Therefore, designing an appropriate Road maintenance policy and strategy, in general, is a prerequisite for the development of a healthy and dependable Road Traffic environment in a country (Office of the Road Fund, 2001).

The road network of the country is rapidly growing as new asphalt and gravel, rural and community roads are built by ERA, RRAs (Rural Road Authorities) and WROs (Woreda Road Offices) respectively every year. Parallel with the rapid expansion of asphalt, gravel, rural and community roads; maintenance need is also growing rapidly. The Office of Road Fund has been collecting revenue mainly from fuel levy and other sources and allocating funds to road agencies for the maintenance of roads since 1997. The revenue and allocation of the Office of Road Fund have steadily been increasing every year since its establishment but have never been enough to meet the maintenance need of the rapidly growing road network of the country (ERA, 2015).

ERA (2015) through the RSDP V report revealed that the gap between the maintenance need of the road network and allocation of the fund has been widening from year to year and as a consequence, more and more roads are left without maintenance every year. Unless a worsening shortage of funds for the maintenance of roads is addressed as early as possible deterioration of road infrastructure will get even worse and worse. This fact is also true at this time (2019/20) as no major change has been seen after 2015. Still, the maintenance need of the road network and allocation of the fund has been widening from year to year as shown in Table 4.3.

To carry out the appropriate maintenance intervention or preserve the road network to its original condition sufficient budget need to be allocated. Back in the years, the Ministry of Finance used to finance road maintenance works. However, this funding arrangement has been

transferred to the Office of the Road Fund and the office has become the sole financer of maintenance works since then.

Accordingly, in the early years of the establishment of the fund office, the budget allocation has been in the proportion of 70% for federal roads, 20% for regional roads and 10% for municipal roads. However, currently, 65% of the regular Road Fund budget is allocated to the Ethiopian Roads Authority towards the maintenance of the federal road network; 25% is allocated to the Regional Road Authorities for rural roads and 10% to the Municipalities for the maintenance of city roads.

This implies that the budget allocation isn't based on road condition maintenance needs. The total Federal Road network of the country at the beginning of the RSDP (1997) was about 15,870 km. Due to the construction of new gravel and asphalt roads during RSDP; the total road network has increased to 20,080 km in the year 2007, 27,606 km in the year 2015 and 29,106 km in 2019/20. In general, the federal road network in Ethiopia has been increasing on average by 3.2% between 1997 and 2020.

It is inevitable that as the road network increases, the maintenance need increases accordingly, thereby increasing the required budget. However, due to the insufficiency of the yearly allocated maintenance budget, it is difficult to provide adequate and timely maintenance to the entire road network. This will have an associated impact on the road user such as an increase in vehicle operating cost and hence reluctance to use the road in addition to increasing the maintenance cost. Table 4.3 shows the requested budget by ERA and allocated budget by Road Fund (RF) and its difference and percentage allocation for the past 10 years.

As indicated in Table 4.3 and Figure 4.3, the yearly allocated budget for maintenance work is much less than the requested budget. It is indicated that the allocated maintenance budget decreases, which doesn't show the constant rate of increase or decrease in proportion to the increasing road network. This is due to the limited amount of income that the office of the Road Found collects from Fuel levy, Axle weight-based vehicle license renewal fee, overloading fines, government budget and any other road tariff as may be fixed and approved by the necessity to finance the road maintenance work.

From the comparison, it is analyzed that the allocated budgets are by far less than the maintenance need of roads and this leads to further road deterioration and loss of the national assets. The average percentage budget allocation between the allocated budget and the maintenance need per year is 47.6 %, which is below 50% of the required budget as per the maintenance need base assessment. This indicates that inadequate financing arrangements/ insufficient budget for road maintenance is one of the problems on road maintenance in the case of federal roads of Ethiopia.

Table 4.3: Requested vs. Allocated budget

Item No.	Budget Year	Requested Budget (ETB)	Allocated Budget by RF (ETB)	Difference (ETB)	% Allocation
1	2010/11	1,772,214,171	715,000,000	1,057,214,171	40.3%
2	2011/12	1,075,906,663	846,500,000	229,406,663	78.7%
3	2012/13	1,637,424,806	931,150,000	706,274,806	56.9%
4	2013/14	1,927,200,000	931,150,000	996,050,000	48.3%
5	2014/15	2,023,560,000	808,316,705	1,215,243,295	39.9%
6	2015/16	2,666,600,000	889,148,375	1,777,451,625	33.3%
7	2016/17	2,960,800,000	1,138,600,000	1,822,200,000	38.5%
8	2017/18	2,742,200,000	1,252,500,000	1,489,700,000	45.7%
9	2018/19	3,087,100,000	1,503,000,000	1,584,100,000	48.7%
10	2019/20	3,593,000,000	1,653,300,000	1,939,700,000	46.0%
Total		**23,486,005,640**	**10,668,665,080**	**12,817,340,560**	
Average Budget Difference & % Allocation				**1,281,734,056**	**47.6%**

(Source: ERA road asset database, 2019/20)

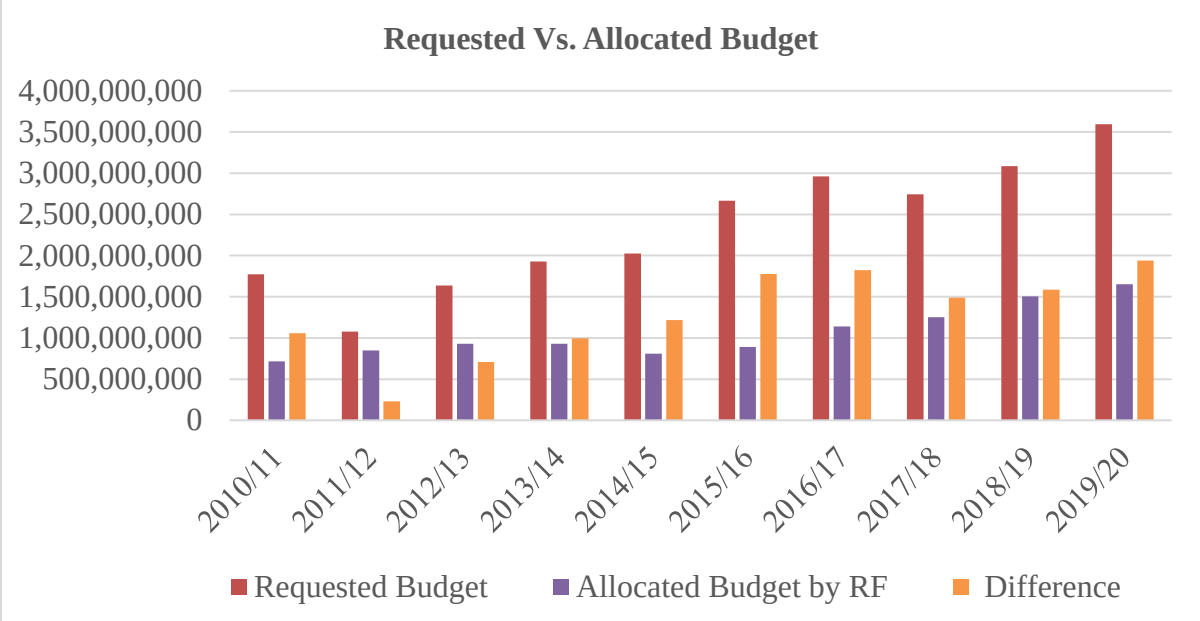

Figure 4.4: Requested Vs. Allocated budget

In relation to the financing of road maintenance, key experts from the Office of Road Fund have been interviewed the following questions which are based on the finding of desk study and their responses are also presented under each question.

Data obtained from ERA reveals that the allocated budget by RF for road maintenance of federal roads is by far less than the requested budget (maintenance need of the roads), the average percentage allocation for the past ten years is 47.6%. In relation to this data, please answer the following questions.

1. In what mechanism does the Office of Road Fund allocate the budget.

a. By conducting the road condition of the country (maintenance need assessment)

b. By fixed proportion (distributing the regular budget through the fixed proportion)

c. If other, please specify;

All of the interviewees were selected option (b) and tipped that the current budget allocating approach is not an effective and appropriate method; hence the approach was adopted since 2000 GC (before 22 years) by considering the road asset value proportions of the roads under ERA, RRAs and Municipalities. During that time, the approach was adopted due to the limitation of human resources, which could conduct maintenance need assessment for roads.

This approach is still not changed, even the assigned proportion for the last 22 years is not updated; which is against the fact on the ground as road asset value might vary each year based on the development of road classes and their network.

2. what are the reasons behind such budget shortfall? All of the interviewees have revealed the following reasons for the budget shortfall.

- ✓ The government's attention on road maintenance is a little.
- ✓ Very limited income option for road maintenance. It is well known that the Office of Road Fund is mainly collecting the income from the fuel levy, which covers around 96% of the annual income of the Office. However, the rate for income collection is not updated for the last 22 years (since 2000 GC). Moreover, recently (since 2016 GC) the Ministry of Ethiopian Revenue and Customs Authority has been holding 50% of fuel levy income to stabilize the market inflation.

4.2.6 Road Maintenance Contracting Method

Like USA DOTs, ERA maintains their federal roads either by using In-House workers through ten (10) Road Maintenance District Managers or by Out-Sourcing the works to private or public contractors; while the supervision is undertaken by private consulting firms and the respective RNSMBDs. In case when RNSMBDs is acting engineer (act like a supervision consultant) for the specific projects, RNMCD acts as a client for those specific projects whereas when supervision is undertaking by private consulting firms, the respective RNSMBDs act as a client for those projects.

While Out-Sourcing the maintenance works to the contractors, ERA often uses the Input-Based Contracting (IBC) method for all of the road maintenance projects except a very few projects, which are undertaking by Output and Performance-based Road Contracting (OPRC) method. Currently, the three pilot road maintenance projects such as Fitche – Gohatsion, Adama – Awash and Adigudem – Wukro are administering through the OPRC method. These three road maintenance projects are maintaining by three public contractors, such as Amhara Roads Construction Enterprise, Ethiopian Construction Works Corporation (ECWC) and

Deference Construction respectively. The contract duration for these projects is ten (10) years, which is relatively longer as compared to road maintenance projects administered through the IBC method. Even though Ethiopia has started maintaining the aforementioned pilot maintenance projects and constructing new road construction project (i.e., for Nekemte - Bure Road Project through three lots) by the OPRC method, OPRC is not advocated very well, whereas nowadays most of the developed countries are using this method considering its importance.

The government of Ethiopia has faced problems in maintaining the serviceability of road infrastructure systems by using these traditional methods of contracting. However, in recent years other alternative contracting methods are attempted including OPRC in the Ethiopian road sector. These types of procurement methods have a substantial success record in many developed and developing countries. Nonetheless, taking the long-term nature of the contract into account, OPRC projects require careful planning and capacity from the contracting authority and the contractor to implement it successfully (Addishiwot, 2019).

Under the In-House method, ERA through ten (10) Road Maintenance District Managers maintain their road networks using their regular staff and equipment. In principle Road Maintenance District Managers are organized to maintain emergency and routine maintenance only and all periodic maintenance projects are planned to be outsourced to private contractors; however, in current practice Road Maintenance District Managers are maintaining all three types of maintenance (i.e., including periodic maintenance) and also private contractors are maintaining periodic and routine maintenance. All emergency maintenances are undertaking only by Road Maintenance District Managers.

4.2.7 Experience of Selected Road Maintenance Projects

From the identified twenty-one (21) road maintenance projects (listed in Annex-3), three projects are selected randomly in order to see their experience in relation to the finding from the questionnaire. The selected three projects are Gedo-Nekemte-Mekenejo routine term maintenance project from Nekemte RNSMBD, Kebridher -Gode -Hargele routine term maintenance project from Diredawa RNSMBD and DoloOdo Junction – Doloby-Hargele Lot-

1 periodic maintenance project from Shashemene RNSMBD. From table 4.4 (the presented data are obtained from the completion and monthly reports of the projects), it is observed that the sole financer of the projects is the Office of Road Fund, and they could not allow any noticeable cost overrun due to the budget limitation. Considering inadequate financing arrangements/ insufficient budget for road maintenance, ERA is strictly monitoring the cost of projects to accomplish the projects within the allocated budget from the Office of Road Fund. Now a day, most road projects have a tendency to cost overrun due to variations, high inflations, etc. However, this is not true in the case of federal road maintenance projects.

On the other hand, time overrun in road maintenance projects in the case of federal roads of Ethiopia are significantly visible, the main reasons behind this general fact are categorized into three.

- ✓ Client-related: such as slow decision-making process,
- ✓ Consultant-related: such as staff unavailability on the site, delay in decision making, poor monitoring and controlling,
- ✓ Contractor-related: such as shortage of equipment (shown in table 4.5), equipment allocation/management problems, poor labor supply and productivity and etc.

Table 4.4: Contractual data of road maintenance projects under different RNSMBD.

It. No.	Project	Financer	Original Contract Amount	Actual Completion Cost	Cost Over Run	% Cost Overrun /Original Amount	Original Contract Duration (Month)	Actual Completi-on Time (Month)	Time Over Run (Month)	% Time Overrun /Original Contract Duration	Re-mark
1	Gedo-Nekemte-Mekenejo Routine Term Maintenance	Office of Road Fund	89,676,546.64	89,252,368.90	-424,177.74	-0.47%	24	42	18	75%	
2	Kebridher - Gode - Hargele Routine Term Mainteance	Office of Road Fund	64,931,045.24	68,666,989.14	3,735,943.90	5.75%	24	29	5	21%	
3	DoloOdo Junction – Doloby-Hargele Lot-1 Periodic Maintenance	Office of Road Fund	39,158,302.24	38,972,839.37	-185,462.87	-0.47%	12	20	8	67%	

The following table shows the contractors' deployment of plant and equipment for the projects during the project work execution period. As shown in the table, very limited equipment was deployed for all of the projects, this has its own negative effects on effective road maintenance as mentioned in section 4.4.3. Even though the difference of project lengths among the aforementioned projects are too significant, the numbers of deployed equipment are nearly similar which is against the projects' actual requirement of the equipment, as the project length and its quantity can determine the required number of the equipment for the projects.

Table 4.5: The deployed plant and equipment for the projects

It. No.	Type of Equipment used in the projects	No. of the equipment used in the projects			Remark
		Gedo-Nekemte-Mekenejo Routine Term Maintenance (367 km in length)	Kebridher -Gode - Hargele Routine Term Maintenance (459 km in length)	DoloOdo Junction – Doloby-Hargele Lot-1 Periodic Maintenance (60 km in length)	
1	Grader	1	2	1	
2	Roller	1	2	1	
3	Loader	1	1	1	
4	Dozer	-	1	-	
5	Excavator	1	1	1	
6	Water Truck	1	2	2	
7	Water pump	-	1	-	
8	Low Bed	1	-	-	
9	Dump Truck	4	6	5	
10	Pickup	3	2	1	
11	Isuzu	1	-	-	

4.3 Basic Information of the Respondents

4.3.1 Distribution and Response Rate

A total of 50 questionnaires were sent to the three groups of respondents in road maintenance projects. Out of 50 questionnaires, 35 questionnaires were collected which comprises 16 from a client (ERA), 6 from the consultants and 13 from the contractors. This gives a response rate of 70% as shown in Table 4.6 below the breakdown of responses from the various sample groups.

An overall response rate of 70% 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 4.6 shows the summary of overall survey response levels.

Table 4.6: Summary of overall survey response level

Group	Questionnaire Distributed	Questionnaire Returned	Percentage Returned (%)
Client (ERA)	20	16	80%
Consultants	9	6	67%
Contractors	21	13	62%
Total	**50**	**35**	**70%**

4.3.2 Academic Background of the Respondents

The purpose of section one was to know the educational and professional capability of respondents to undertake the work. The questionnaire was to be completed by respondents who were involved/involving in road maintenance projects.

The survey result shows that 34.3% of the respondents have a MSc degree educational qualification and the rest 65.7% have a BSc degree educational qualification as shown in

Figure 4.4. The percentage distribution of the various professionals indicates that the majority of the questionnaires were completed directly by professionals involved in road maintenance projects. The survey also shows that it was well represented by better-qualified professionals in road maintenance and these groups of respondents are expected to have plenty of knowledge on the subject matter.

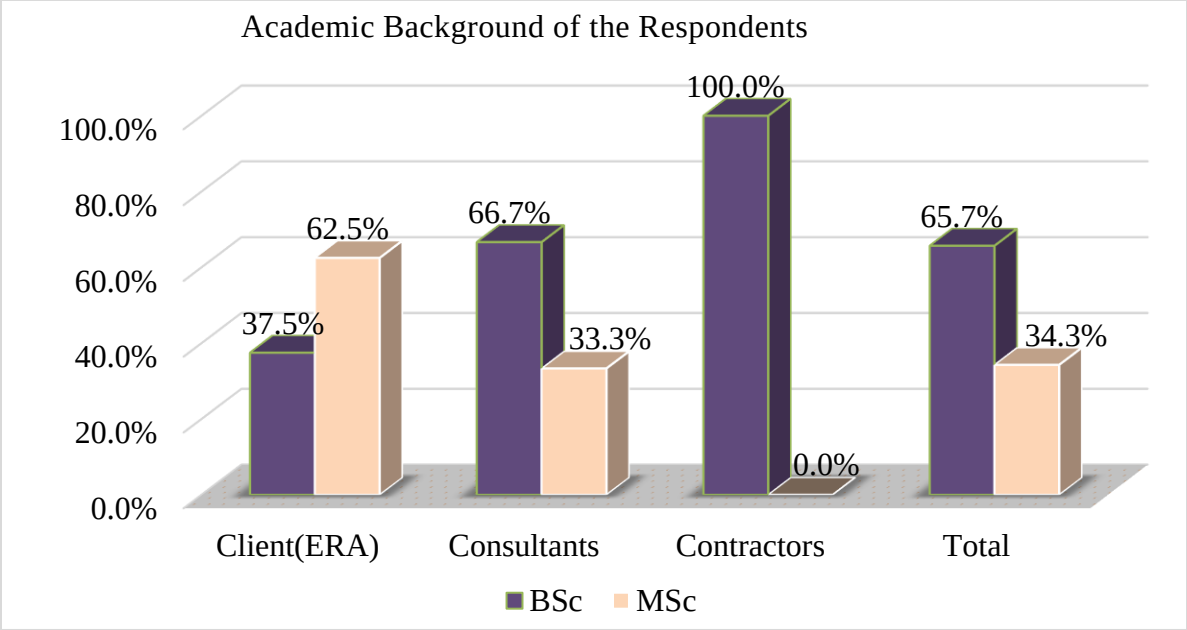

Figure 4.5: Academic background of the respondents

4.3.3 Respondents Work Experience in Road Maintenance Projects

Out of the 16 respondents by the client-side 18.8% of respondents had less than 5 years of working experience, 68.7% had 5 to 10 years of experience and 12.5% had 10 to 15 years of experience in Road Maintenance Projects.

Out of the 6 respondents by the consultant, 16.7% of the respondents had less than 5 years of working experience, 66.6% had 5 to 10 years of experience and 16.7% had 10 to 15 years of experience in Road Maintenance Projects.

Out of the 13 respondents by the contractor 76.9% of respondents had less than 5 years of working experience, 15.4% had 5 to 10 years of experience and 7.7% had 10 to 15 years of experience in Road Maintenance Projects.

In general, out of the 35 respondents, the data depicted below shows that 40% of the respondents had less than 5 years of personal working experience, 48.6% had 5 to 10 years of experience and 11.4% had 10 to 15 years of experience in road maintenance projects as shown in Figure 4.5 below.

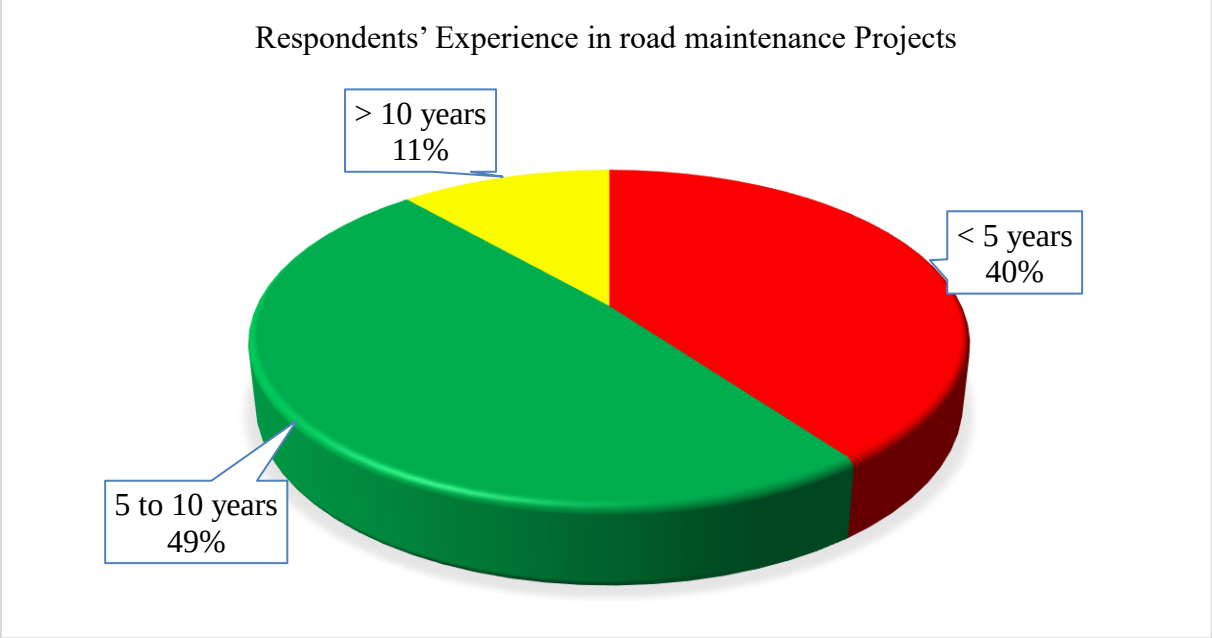

Figure 4.6: Respondents' personal experience in road maintenance projects

4.4 Problems of Road Maintenance

Identification of the problems of road maintenance was exhaustively done through literature review and informal discussion made with ERA officials and professionals in the sector. Accordingly, a total of sixty-seven (67) problems were identified under four categories, namely client-related problems, consultant-related problems, contractor-related problems and other problems. Summary of the numbers of problems identified under each category is presented in Table 4.7.

Table 4.7: Number of identified problems on road maintenance

Categories	No. of Identified Problems	Percentage (%)
Client-related problems	20	29.9%
Consultant-related problems	18	26.9%
Contractor-related problems	18	26.9%
Other problems	11	16.4%
Total	**67**	**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 ERA 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. In addition to this, Spearman's-rank correlation coefficient was calculated to show the degree of agreement between the different parties involved in the survey.

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 3.1. 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 their magnitudes in the case of federal roads Ethiopia) by considering that it can present the overall views of those who are involving in the road maintenance.

4.4.1 Client-related Problems

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 and Spearman's-rank correlation coefficients between the respondents.

There are twenty (20) client-related problems in road maintenance that were identified from the literature reviews and 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 4.8 shows responses by RII of the client, consultants, contractors and combined on client-related problems in road maintenance. These problems were ranked accordingly.

Table 4.8: Participants RII and rank of client-related problems

Code	Client-related Problems	Client		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
A-1	Procurement delay	0.923	1	0.867	1	0.886	1	0.900	1
A-2	Insufficient road condition survey with lack of appropriate project prioritization mechanism	0.831	2	0.833	2	0.857	2	0.838	2
A-3	Slow decision-making process	0.800	3	0.733	5	0.829	3	0.792	3
A-4	Not managing the roads as part of the market economy (Roads are managed like a social service)	0.692	8	0.767	3	0.743	4	0.723	4
A-5	Not advocating Performance-Based Contracting system.	0.800	3	0.733	5	0.514	12	0.708	5
A-6	Lack of effective budget consumption (allocated budget is not consumed effectively)	0.800	3	0.700	7	0.543	10	0.708	5
A-7	Not advocating PPP in road maintenance	0.692	8	0.767	3	0.600	6	0.685	7
A-8	Weak management systems	0.754	7	0.600	9	0.543	10	0.662	8
A-9	High turnover of senior staff (Leaving of senior staff)	0.785	6	0.567	11	0.514	12	0.662	8

Code	Client-related Problems	Client		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
A-10	Lack of capacity-building training for client staff, contractors and consultants involving in maintenance	0.677	10	0.600	9	0.657	5	0.654	10
A-11	Not hiring supervision consultants for all maintenance projects.	0.662	12	0.633	8	0.600	6	0.638	11
A-12	Poor communication with stakeholders	0.631	16	0.567	11	0.571	8	0.600	12
A-13	Change of plan and scope of the project	0.662	12	0.567	11	0.514	12	0.600	12
A-14	Human resource constraints	0.677	10	0.500	15	0.486	16	0.585	14
A-15	Corruption	0.631	16	0.467	17	0.571	8	0.577	15
A-16	Lack of communication and coordination by the client itself	0.646	14	0.500	15	0.486	16	0.569	16
A-17	Difficult bureaucracy in the client organization	0.554	20	0.567	11	0.514	12	0.546	17
A-18	Repeated change order and variation order	0.615	18	0.467	17	0.457	18	0.538	18
A-19	Poor organization structures	0.646	14	0.400	20	0.429	19	0.531	19
A-20	Lack of qualified client staff	0.600	19	0.467	17	0.400	20	0.515	20

4.4.1.1 Client's Point of View

As shown in Table 4.8, the respondents from the client-side ranked procurement delay (RII=0.923) as the most significant client-related problem in road maintenance; and insufficient road condition survey with lack of appropriate project prioritization mechanism (RII=0.831) is ranked as the second significant client-related problem in road maintenance.

Fortunately, the respondents from the consultants' and contractors' sides had ranked the same for the aforementioned problems. This indicates that most of the respondents have the same opinion on these two problems; hence, ERA shall consider them while undertaking any road maintenance in order to alleviate the mentioned problems and minimize their effects.

Following these, slow decision-making process, not advocating Performance-Based Contracting system and lack of effective budget consumption (allocated budget is not

consumed effectively) are the third significant client-related problems in road maintenance with the same value (RII =0.800).

According to the respondents of this category, difficult bureaucracy in the client organization (RII=0.554) is ranked as the least significant client-related problem in road maintenance.

4.4.1.2 Consultants' Point of View

The same to respondents from the client-side, the consultants' respondents have ranked procurement delay and insufficient road condition survey with lack of appropriate project prioritization mechanism as the most significant client-related problems in road maintenance with the value of RII=0.867 and RII=0.833 respectively.

Following these, not managing the roads as part of the market economy (Roads are managed like a social service) and not advocating PPP in road maintenance are the third significant client-related problems in road maintenance with the same value (RII =0.767). The slow decision-making process and not advocating Performance-Based Contracting system are the fifth significant client-related problems in road maintenance with the same value (RII =0.733).

According to the respondents of this category, poor organization structures (RII=0.400) is ranked as the least significant client-related problem in road maintenance.

4.4.1.3 Contractors' Point of View

Like the respondents from the client and consultants' side, the contractors' respondents have ranked procurement delay and insufficient road condition survey with lack of appropriate project prioritization mechanism as the most significant client-related problems in road maintenance with the value of RII=0.886 and RII=0.857 respectively.

Following these, slow decision-making process, not managing the roads as part of the market economy (Roads are managed like a social service) are the third and fourth significant client-related problems in road maintenance with the value of RII=0.829 and RII=0.743 respectively. Lack of capacity-building training for client staff, contractors and consultants involving in maintenance is the fifth significant client-related problem in road maintenance with the value of RII =0.657.

According to the respondents of this category, lack of qualified client staff (RII=0.400) is ranked as the least significant client-related problem in road maintenance.

4.4.1.4 View of the Combined Result

As shown in Table 4.8, the combined RII and Rank for each client-related problem were analyzed by taking the responses of the overall respondents from the three parties. Accordingly, out of twenty (20) identified client-related problems in road maintenance, the top ten (10) ranked problems with the RII value of greater than 0.650 are discussed below and shown in Figure 4.6. Even though all the problems have the RII value of greater than 0.500, 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 this category have the highest degree of significance. Based on the result of client-related problems, procurement delay and insufficient road condition survey with lack of appropriate project prioritization mechanism have the RII value of between 0.800 and 1.00, which shows that these problems have a very high degree of significance in road maintenance.

Whereas, the problems such as slow decision-making process, not managing the roads as part of the market economy (Roads are managed like a social service), not advocating Performance-Based Contracting system, lack of effective budget consumption (allocated budget is not consumed effectively), not advocating PPP in road maintenance, weak management systems, high turnover of senior staff (leaving of senior staff) and lack of capacity-building training for client staff, contractors and consultants involving in maintenance have the RII value of between 0.600 and 0.800, which shows that the problems have a high degree of significance in road maintenance. The RII and the rank of each problem are shown in Figure 4.6 and Table 4.8.

All of these problems were selected as significant and very significant by most of the respondents and therefore, they are the most significant client-related problems in road maintenance; hence, ERA shall consider them while undertaking any road maintenance in order to alleviate the mentioned problems and minimize their effects.

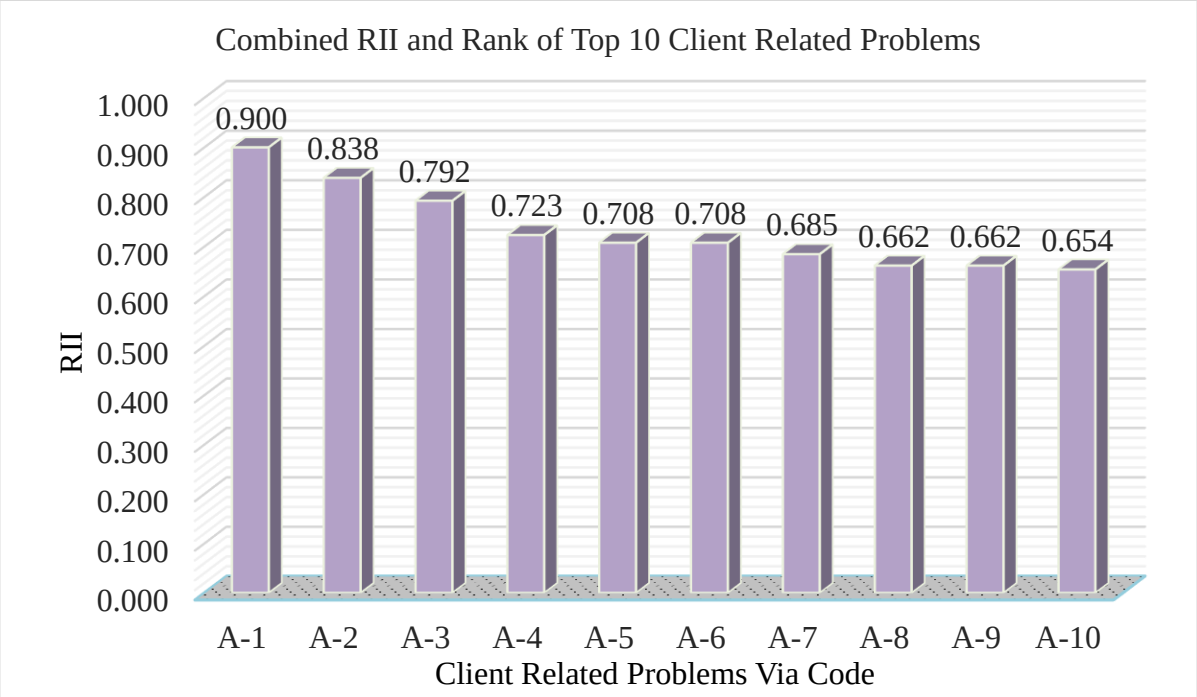

Figure 4.7: Combined RII and rank of the top 10 client-related problems

4.4.1.5 Spearman's Correlation Between the Parties

One of the purposes of this thesis is to investigate whether there is an agreement on the attitudes of parties towards the problems of road maintenance in the case of Federal Roads of Ethiopia or not. Hence, in this section respondents' responses were tested for correlation using Spearman rank correlation coefficients, to see the degree of agreement between two groups of respondents; these are client versus consultants, client versus contractors and consultants versus contractors on the client-related problems.

Table 4.9 shows Spearman's correlation between the client, consultant and contractor on client-related problems. From the correlation coefficient result, it can be concluded that there is a strong relationship between the attitudes of the respondents in the client-consultant and client-contractor. This indicates that most of the respondents have the same attitudes and perceptions towards the client-related problems in road maintenance. It's also concluded that there is a very strong relationship between the attitudes of the respondents in the consultant-contractor. This indicates that almost all of the respondents from the consultants' and contractors' sides have the same attitudes and perceptions towards the client-related problems in road maintenance.

Table 4.9: Spearman's correlation test result on the ranking of client-related problems

Respondents	Spearman's Rank Correlation coefficient (r_s)	Relation of the Respondents
Client vs. Consultants	0.778	Strong
Client vs. Contractors	0.614	Strong
Consultants vs. Contractors	0.850	Very Strong

4.4.2 Consultant-related Problems

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 and Spearman's-rank correlation coefficients between the respondents.

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

Table 4.10 shows responses by RII of the client, consultants, contractors and combined on consultant-related problems in road maintenance. These problems were ranked accordingly.

Table 4.10: Participants RII and rank of consultant-related problems

Code	Consultant-related Problems	Client		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
B-1	Staff unavailability on the site	0.831	1	0.600	8	0.857	1	0.785	1
B-2	Insufficient data collection and condition survey before road maintenance	0.815	2	0.667	4	0.829	2	0.785	1
B-3	Delay in decision making	0.800	4	0.700	2	0.800	3	0.777	3
B-4	No specialized consultants on the road maintenance	0.815	2	0.633	6	0.771	4	0.762	4
B-5	Inadequate maintenance experiences of consultants	0.784	5	0.633	6	0.771	4	0.746	5
B-6	Shortage of technically qualified personnel/staff	0.769	6	0.733	1	0.686	10	0.738	6

Code	Consultant-related Problems	Client		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
B-7	Inadequate maintenance experiences of consultant staff	0.723	10	0.667	4	0.743	6	0.715	7
B-8	Poor monitoring and controlling	0.754	7	0.533	11	0.743	6	0.700	8
B-9	High turnover of consultant staff (Leaving of consultant staff)	0.708	11	0.700	2	0.657	12	0.692	9
B-10	Quality assurance/control problems	0.754	7	0.567	9	0.686	10	0.692	9
B-11	Corruption	0.738	9	0.433	17	0.714	8	0.662	11
B-12	Poorly qualified engineers and staff assigned to the project	0.692	13	0.500	14	0.714	8	0.654	12
B-13	Late approval of test	0.661	15	0.567	9	0.657	12	0.638	13
B-16	Poor maintenance contract management and project administration	0.708	11	0.500	14	0.629	15	0.638	13
B-14	Poor inspection and testing	0.677	14	0.533	11	0.600	17	0.623	15
B-15	Poor communication and coordination of the consultant with other parties	0.662	15	0.500	14	0.657	12	0.623	15
B-17	No/little knowledge of maintenance specification	0.646	17	0.533	11	0.629	15	0.615	17
B-18	Lack of interest by consultants to conduct laboratory and field tests	0.631	18	0.433	17	0.514	18	0.554	18

4.4.2.1 Client's Point of View

As shown in Table 4.10, the respondents from the client-side ranked staff unavailability on the site (RII=0.831) as the most significant consultant-related problem in road maintenance; and insufficient data collection and condition survey before road maintenance and no specialized consultants on road maintenance are ranked as the second significant consultant-related problem in road maintenance with the same value (RII=0.815). Similarly, these three problems are also got the top ranks in the respondents of contractors. This indicates that most of the respondents from the client and contractors have the same opinion on these three problems; hence, the consultants shall consider them while undertaking any road maintenance in order to alleviate the mentioned problems and minimize their effects.

Following these, delay in decision making and inadequate maintenance experience of the consultants are the fourth and fifth significant consultant-related problems in road maintenance with the value of RII=0.800 and RII=0.784 respectively.

According to the respondents of this category, the lack of interest by consultants to conduct laboratory and field tests (RII=0.631) is ranked as the least significant consultant-related problem in road maintenance.

4.4.2.2 Consultants' Point of View

In the contrary to respondents from the client and contractor side, the consultants' respondents have ranked shortage of technically qualified personnel/staff (RII=0.733) as the most significant consultant-related problem in road maintenance. Delay in decision making and high turnover of consultant staff (leaving of consultant staff) are ranked as the second significant consultant-related problem in road maintenance with the same value of RII=0.700.

Following these, insufficient data collection and condition survey before road maintenance and inadequate maintenance experiences of consultant staff are the fourth significant consultant-related problems in road maintenance with the same value (RII =0.667).

According to the respondents of this category, corruption and lack of interest by consultants to conduct laboratory and field tests are ranked as the least significant consultant-related problems in road maintenance with the same value (RII = 0.433).

From the result shown in Table 4.10, it can be concluded that the consultants' perspective towards the consultant-related problems is somehow overprotective, i.e., they are protecting themselves from revealing or accepting their significant problems. For instance, the most significant consultant-related problem (staff unavailability on the site) is ranked as the first by both client and contractors with the RII value of 0.831 & 0.857. However, this problem is ranked as eighth (8^{th}) by the consultants with the RII value of 0.600, which is so far as compared to others. As ERA is paying for the consultants by considering the residence of all their staff on the project site, the consultants are 100 percent responsible for any consequences due to this problem; even, the consultants will be liable as per professional ethics. Fearing this,

the consultants are being protective of themselves from revealing or accepting their significant problems.

4.4.2.3 Contractors' Point of View

Like the respondents from the client-side, the contractors' respondents have ranked staff unavailability on the site and insufficient data collection and condition survey before road maintenance as the most significant consultant-related problems in road maintenance with the value of RII=0.857 and RII=0.829 respectively.

Following these, delay in decision making is the third significant consultant-related problem in road maintenance with the value of RII=0.800. No specialized consultants on road maintenance and inadequate maintenance experience of the consultants are the fourth significant consultant-related problems in road maintenance with the same value of RII=0.771.

According to the respondents of this category, the lack of interest by consultants to conduct laboratory and field tests (RII=0.514) is ranked as the least significant consultant-related problem in road maintenance.

4.4.2.4 View of the Combined Result

As shown in Table 4.10, 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 eighteen (18) identified consultant-related problems in road maintenance, the top ten (10) ranked problems with RII value greater than 0.690 are discussed below and shown in Figure 4.8. Even though all the identified problems have the RII value of greater than 0.550, only the top ten problems are selected for discussions in order to focus on the most significant problems.

As shown in Figure 4.8 below, the problems of this category have a high degree of significance. Based on the result of consultant-related problems, all of the top 10 consultant-related problems such as staff unavailability on the site, insufficient data collection and condition survey before road maintenance, delay in decision making, no specialized consultants on the road maintenance, inadequate maintenance experiences of consultants, shortage of technically

qualified personnel/staff, inadequate maintenance experiences of consultant staff, poor monitoring and controlling, high turnover of consultant staff (leaving of consultant staff) and quality assurance/control problems have the RII value of between 0.600 and 0.800, which shows that the problems have a high degree of significance in road maintenance. The RII and the rank of each problem are shown in Figure 4.8 and Table 4.10.

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 their effects.

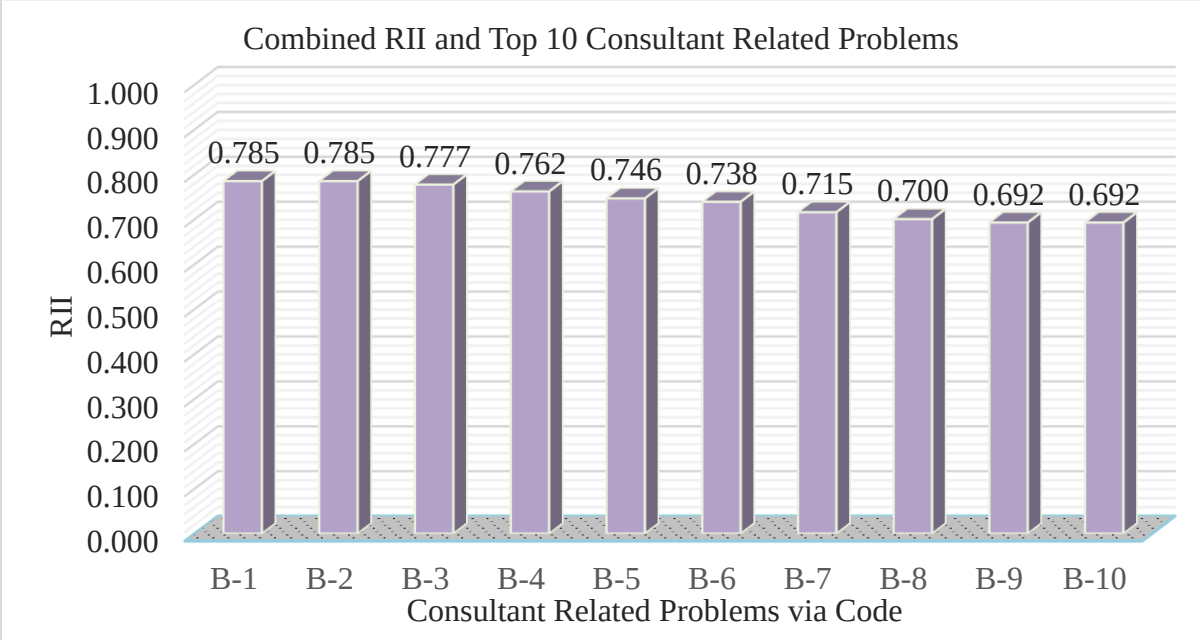

Figure 4.8: Combined RII and rank of the top 10 consultant-related problems

4.4.2.5 Spearman's Correlation Between the Parties

In this section, respondents' responses were tested for correlation using Spearman rank correlation coefficients, to see the degree of agreement between two groups of respondents; these are client versus consultants, client versus contractors and consultants versus contractors on the consultant-related problems.

Table 4.11 shows Spearman's correlation between the client, consultant and contractor on consultant-related problems. From the correlation coefficient result, it can be concluded that there is a moderate relationship between the attitudes of the respondents in the client-consultant and consultant-contractor. This implies that consultants have moderately different attitudes and perceptions with the client and contractors towards the consultant-related problems in road maintenance. It's also concluded that there is a very strong relationship between the attitudes of the respondents in the client-contractor. This indicates that almost all of the respondents from the client and contractors' sides have the same attitudes and perceptions towards the consultant-related problems in road maintenance.

Table 4.11: Spearman's correlation test on the ranking of consultant-related problems

Respondents	Spearman's Rank Correlation coefficient (r_s)	Relation of the Respondents
Client vs. Consultants	0.594	Moderate
Client vs. Contractors	0.874	Very Strong
Consultants vs. Contractors	0.528	Moderate

4.4.3 Contractor-related problems

The results of this part of the study provide an indication of the participants and combined relative importance index (RII) and rank of contractor-related problems in road maintenance and Spearman's-rank correlation coefficients between the respondents.

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

Table 4.12 shows responses by RII of the client, consultants, contractors and combined on contractor-related problems in road maintenance. These problems were ranked accordingly.

Table 4.12: Participants RII and rank of contractor-related problems

Code	Contractor-related problems	Client		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
C-1	Shortage of equipment	0.892	1	0.767	3	0.829	1	0.846	1
C-2	Equipment allocation/management problems	0.877	2	0.700	8	0.771	3	0.808	2
C-3	Lack of acquiring new and recent technology equipment	0.846	3	0.800	2	0.657	7	0.785	3
C-4	Not managing resources efficiently and effectively	0.831	4	0.767	3	0.686	5	0.777	4
C-5	Incompatibility with new technology	0.815	5	0.833	1	0.629	9	0.769	5
C-6	Poor labor supply and productivity	0.769	7	0.733	5	0.714	4	0.746	6
C-7	Insolvencies and bankruptcies or cash flow problem	0.708	14	0.700	8	0.800	2	0.731	7
C-8	No specialized contractors on road maintenance	0.785	6	0.700	8	0.629	9	0.723	8
C-9	Inadequate experience of contractor's staff	0.754	8	0.733	5	0.629	9	0.715	9
C-10	Inefficient work methods	0.723	11	0.700	8	0.600	12	0.685	10
C-11	Poor maintenance contract management and project administration	0.723	11	0.733	5	0.571	15	0.685	10
C-12	Inadequate maintenance experience of contractors	0.738	9	0.667	12	0.571	15	0.677	12
C-13	Corruption	0.738	9	0.633	15	0.600	12	0.677	12
C-14	High turnover of contractor's staff (Leaving of contractor's staff)	0.662	17	0.633	15	0.686	5	0.662	14
C-15	Shortage of technically qualified personnel/staff	0.708	14	0.667	12	0.571	15	0.662	14
C-16	Poor communication and coordination of the contractor with other parties	0.708	14	0.633	15	0.600	12	0.662	14
C-17	Poor site management	0.723	11	0.667	12	0.543	18	0.662	14
C-18	Poor demand and supply chain	0.662	17	0.633	15	0.657	7	0.654	18

4.4.3.1 Client's Point of View

As shown in Table 4.12, the respondents from the client-side ranked staff shortage of equipment (RII=0.892) as the most significant contractor-related problem in road maintenance; and equipment allocation/management problems (RII=0.877) is ranked as the second significant contractor-related problem in road maintenance. Similarly, these two problems are

also got the top ranks in the respondents of contractors. This indicates that most of the respondents from the client and contractors have the same opinion on these two problems; hence, the contractor shall consider them while undertaking any road maintenance in order to alleviate the mentioned problems and minimize their effects.

Following these, the lack of acquiring new and recent technology equipment, not managing resources efficiently and effectively and incompatibility with new technology are the third, fourth and fifth significant contractor-related problems in road maintenance with the value of RII=0.846, RII=0.831 and RII=0.815 respectively.

According to the respondents of this category, high turnover of contractor's staff (leaving of contractor's staff) and poor demand and supply chain are ranked as the least significant contractor-related problems in road maintenance with the same value (RII = 0.622).

4.4.3.2 Consultants' Point of View

The consultants' respondents have ranked incompatibility with new technology and lack of acquiring new and recent technology equipment as the most significant contractor-related problems in road maintenance with the value of RII=0.833 and RII=0.800 respectively.

Following these, shortage of equipment and not managing resources efficiently and effectively are the third significant contractor-related problems in road maintenance with the same value of RII=0.767. Poor labor supply and productivity, inadequate experience of contractor's staff and poor maintenance contract management and project administration are the fifth significant contractor-related problems in road maintenance with the same value of RII=0.733.

According to the respondents of this category, corruption, high turnover of contractor's staff (leaving of contractor's staff), poor communication and coordination of the contractor with other parties and poor demand and supply chain are ranked as the least significant contractor-related problems in road maintenance with the same value (RII = 0.633).

4.4.3.3 Contractors' Point of View

Similar to the respondents from the client-side, the contractors' respondents have ranked shortage of equipment as the most significant contractor-related problem in road maintenance

with the value of RII=0.829. In contrary to the respondents from the client and consultant side, the contractors' respondents have ranked insolvencies and bankruptcies or cash flow problem as the second significant contractor-related problem in road maintenance with the value of RII=0.800.

Following these, equipment allocation/management problems and poor labor supply and productivity are the third and fourth significant contractor-related problems in road maintenance with the value of RII=0.771 and RII=0.714 respectively. Not managing resources efficiently and high turnover of contractor's staff (leaving of contractor's staff) are fifth significant contractor-related problems in road maintenance with the same value of RII=0.686.

According to the respondents of this category, poor site management is ranked as the least significant contractor-related problem in road maintenance with the value of RII=0.543.

From the result shown in Table 4.12, it can be concluded that the contractors' perspective towards some of the contractor-related problems is somehow overprotective, i.e., they are protecting themselves from revealing or accepting some of their significant problems. For instance, some of the most significant contractor-related problems such as lack of acquiring new and recent technology equipment and incompatibility with new technology are ranked in the top five by both client and consultants with the RII value of greater than 0.800. However, these problems are ranked as seventh (7^{th}) and ninth (9^{th}) by the contractors with the RII value of 0.657 & 0.629 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.

4.4.3.4 View of the Combined Result

As shown in Table 4.12, 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 ten (10) ranked problems with RII value greater than 0.680 are discussed below and

shown in Figure 4.9. Even though all the problems have the RII value of greater than 0.650, only the top ten ranked problems are selected for discussions in order to focus on the most significant problems.

As shown in Figure 4.9, the problems of this category have the highest degree of significance. Based on the result of contractor-related problems, shortage of equipment and equipment allocation/management problems have the RII value of between 0.800 and 1.00, which shows that these two problems have a very high degree of significance in road maintenance.

Whereas, the problems such as lack of acquiring new and recent technology equipment, not managing resources efficiently and effectively, incompatibility with new technology, poor labor supply and productivity, insolvencies and bankruptcies or cash flow problem, no specialized contractors on road maintenance, inadequate experience of contractor's staff, inefficient work methods and poor maintenance contract management and project administration have the RII value of between 0.600 and 0.800, which shows that the problems have a high degree of significance in road maintenance. The RII and the rank of each problem are shown in Figure 4.9 and Table 4.12.

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 their effects.

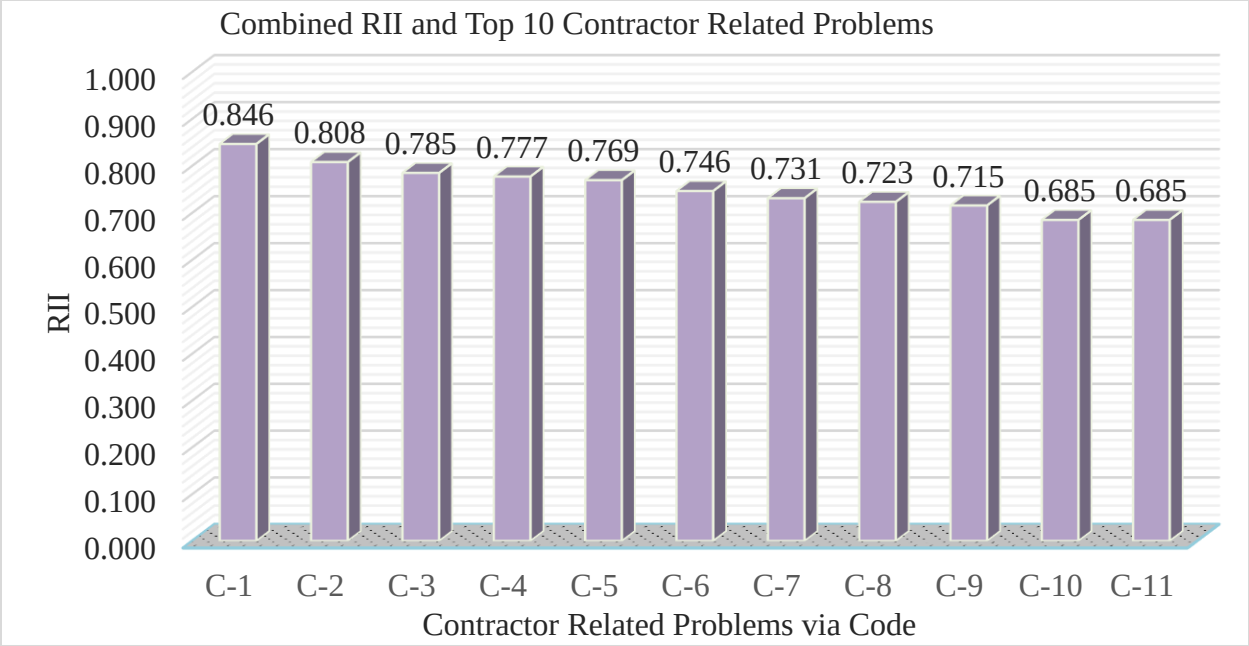

Figure 4.9: Combined RII and rank of the top 10 contractor-related problems

4.4.3.5 Spearman's Correlation Between the Parties

In this section, respondents' responses were tested for correlation using Spearman rank correlation coefficients, to see the degree of agreement between two groups of respondents; these are client versus consultants, client versus contractors and consultants versus contractors on the contractor-related problems.

Table 4.13 shows Spearman's correlation between the client, consultant and contractor on contractor-related problems. From the correlation coefficient result, it can be concluded that there is a strong relationship between the attitudes of the respondents in the client-consultant. This indicates that almost all of the respondents from the client and consultants' side have the same attitudes and perceptions towards the contractor-related problems in road maintenance. It's also concluded that there is a moderate relationship between the attitudes of the respondents in the client-contractor and consultant-contractor. This implies that contractors have moderately different attitudes and perceptions with the client and consultants towards the contractor-related problems in road maintenance.

Table 4.13: Spearman's correlation test on the ranking of contractor-related problems

Respondents	Spearman's Rank Correlation coefficient (r_s)	Relation of the Respondents
Client vs. Consultants	0.778	Strong
Client vs. Contractors	0.425	Moderate
Consultants vs. Contractors	0.455	Moderate

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 and Spearman's-rank correlation coefficients between the respondents.

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 eleven (11) other problems in road maintenance that were identified from the literature reviews and informal discussion with professionals in the sector and the major problems are discussed below.

Table 4.14 shows responses by RII of the client, consultants, contractors and combined on other problems in road maintenance. These problems were ranked accordingly.

Table 4.14: Participants RII and rank of other problems

Code	Other Problems	Client		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
D-1	People in power have a little understanding on the effects of poor road maintenance	0.908	1	0.800	3	0.829	1	0.862	1
D-2	Road maintenance is politically unattractive	0.815	4	0.900	1	0.686	3	0.800	2
D-3	Lack of interest by professionals to participate in road maintenance works	0.892	2	0.733	7	0.657	5	0.792	3
D-4	Working with maintenance is still looked up as a low-status occupation (undermining road maintenance works)	0.831	3	0.867	2	0.629	6	0.785	4
D-5	Road Maintenance has not been looked upon by universities as an intellectual subject	0.769	6	0.767	5	0.771	2	0.769	5
D-6	Inadequate financing arrangements/ insufficient budget for road maintenance.	0.769	6	0.800	3	0.686	3	0.754	6
D-7	People in power have little/no knowledge /understanding of road maintenance	0.800	5	0.767	5	0.629	6	0.746	7
D-8	Donors are not interested to fund road maintenance	0.677	9	0.667	9	0.600	8	0.654	8
D-9	The financial source for road maintenance is limited (only road fund)	0.631	10	0.700	8	0.600	8	0.638	9
D-10	Foreign contractors are not interested to participate in road maintenance	0.723	8	0.567	11	0.514	11	0.631	10
D-11	Road users are not directly paying for roads	0.554	11	0.600	10	0.543	10	0.562	11

4.4.4.1 Client's Point of View

As shown in Table 4.14, the respondents from the client-side ranked people in power have a little understanding on the effects of poor road maintenance (RII=0.908) and lack of interest by professionals to participate in road maintenance works (RII=892) as the most significant other problems in road maintenance.

Following these, working with maintenance is still looked up as a low-status occupation (undermining road maintenance works), road maintenance is politically unattractive and people in power have little/no knowledge /understanding of road maintenance are the third,

fourth and fifth significant other problems in road maintenance with the value of RII=0.831, RII=0.815 and RII=0.800 respectively.

According to the respondents of this category, road users are not directly paying for roads is ranked as the least significant other problem in road maintenance with the same value of RII = 0.554.

4.4.4.2 Consultants' Point of View

The consultants' respondents have ranked road maintenance is politically unattractive and working with maintenance is still looked up as a low-status occupation (undermining road maintenance works) as the most significant other problems in road maintenance with the value of RII=0.900 and RII=0.867 respectively.

Following these, people in power have a little understanding on the effects of poor road maintenance and inadequate financing arrangements/ insufficient budget for road maintenance are the third significant other problems in road maintenance with the same value of RII=0.800. Road Maintenance has not been looked upon by universities as an intellectual subject and people in power have little/no knowledge /understanding of road maintenance are the fifth significant other problems in road maintenance with the same value of RII=0.767.

According to the respondents of this category, road users do not directly pay for roads is ranked as the least significant other problem in road maintenance with the same value of RII = 0.554.

4.4.4.3 Contractors' Point of View

Similar to the respondents from the client-side, the contractors' respondents have ranked people in power have a little understanding on the effects of poor road maintenance as the most significant other problem in road maintenance with the value of RII=0.829. In the contrary, road maintenance has not been looked upon by universities as an intellectual subject is ranked as the second significant other problem in road maintenance with the value of RII=0.771.

Following these, road maintenance is politically unattractive and inadequate financing arrangements/ insufficient budget for road maintenance are the third significant other problems in road maintenance with the same value of RII=0.686. Lack of interest by professionals to

participate in road maintenance works is the fifth significant other problems in road maintenance with the same value of RII=0.657.

According to the respondents of this category, foreign contractors are not interested to participate in road maintenance is ranked as the least significant other problem in road maintenance with the value of RII=0.514.

4.4.4.4 View of the Combined Result

As shown in Table 4.14, 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 eleven (11) identified other problems in road maintenance, the top seven (7) problems with RII value greater than 0.700 are discussed below and shown in Figure 4.10. Even though all the problems have the RII value of greater than 0.550, only the top seven ranked problems are selected for discussions in order to focus on the most significant problems.

As shown in Figure 4.10, the problems of this category have the highest degree of significance. Based on the result of other problems, people in power have a little understanding on the effects of poor road maintenance and Road maintenance is politically unattractive have the RII value of between 0.800 and 1.00, which shows that these two problems have a very high degree of significance in road maintenance.

Whereas the problems such as lack of interest by professionals to participate in road maintenance works, working with maintenance is still looked up as a low-status occupation (undermining road maintenance works), road maintenance has not been looked upon by universities as an intellectual subject, inadequate financing arrangements/ insufficient budget for road maintenance and people in power have little/no knowledge /understanding of road maintenance have the RII value of between 0.600 and 0.800, which shows that the problems have a high degree of significance in road maintenance. The RII and the rank of each problem are shown in Figure 4.10 and Table 4.14.

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 their effects.

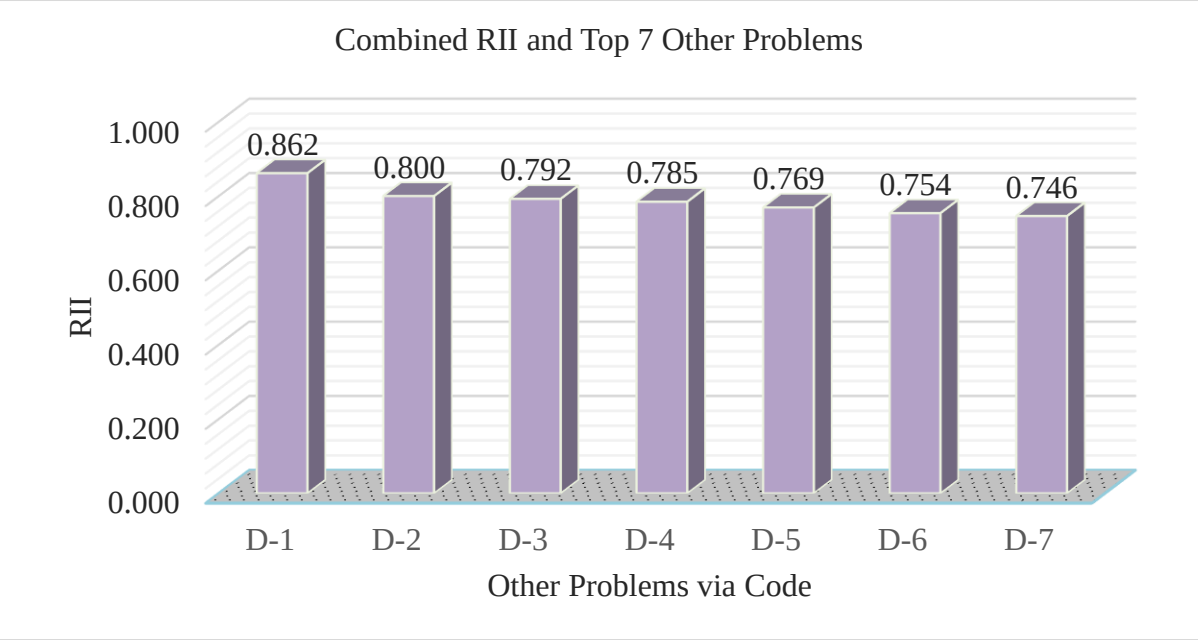

Figure 4.10: Combined RII and rank of the top 7 other problems

4.4.4.5 Spearman's Correlation Between the Parties

In this section, respondents' responses were tested for correlation using Spearman rank correlation coefficients, to see the degree of agreement between two groups of respondents; these are client versus consultants, client versus contractors and consultants versus contractors on the other problems.

Table 4.15 shows Spearman's correlation between the client, consultant and contractor on other problems. From the correlation coefficient result, it can be concluded that there is a strong relationship between the attitudes of the respondents in the client-consultant, client-contractor and very strong relationship between the attitudes of the respondents in the consultant-contractor. This indicates that almost all of the respondents from the client, consultants' and contractors' sides have the same attitudes and perceptions towards the other problems in road maintenance.

Table 4.15: Spearman's correlation test on the ranking of other problems

Respondents	Spearman's Rank Correlation coefficient (r_s)	Relation of the Respondents
Client vs. Consultants	0.780	Strong
Client vs. Contractors	0.790	Strong
Consultants vs. Contractors	0.864	Very Strong

4.5 Effects of Poor Road Maintenance on Road Function

Identification of the effects of poor road maintenance on road function were exhaustively done through literature review and informal discussions made with ERA officials and professionals in the sector. Accordingly, a total of sixteen (16) effects were identified and shown in Table 4.16.

In the structured part of the questionnaire, the respondents were asked to rate the frequency of the effects/variables drawn from the literature review and informal discussion made with ERA 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 frequently occurring effects. In addition to this, Spearman's-rank correlation coefficient was calculated to show the degree of agreement between the different parties involved in the survey.

Table 4.16 shows responses by RII of the client, consultants, contractors and combined on the effects of poor road maintenance on road function. These effects were ranked accordingly and the major effects are discussed below.

Table 4.16: Participants RII and rank of the effects of poor road maintenance on road function

Code	Effects	Client		Consultant		Contractor		Combined	
		RII	Rank	RII	Rank	RII	Rank	RII	Rank
E-1	Reduce the riding comfort	0.877	2	0.933	1	0.971	1	0.915	1
E-2	Shorten service/design life of the roads	0.908	1	0.900	2	0.857	6	0.892	2
E-3	Increase vehicle operating costs	0.846	3	0.833	4	0.914	3	0.862	3
E-4	Increase the rate of road deterioration	0.846	3	0.867	3	0.829	9	0.846	4
E-5	Decrease road users' satisfaction	0.815	6	0.800	7	0.943	2	0.846	4
E-6	Deny faster and better flow of transport services	0.815	6	0.833	4	0.886	4	0.838	6
E-7	Dwarf economic development and growth of a country	0.815	6	0.833	4	0.857	6	0.831	7
E-8	Initiates public complaint on the government	0.815	6	0.800	7	0.857	6	0.823	8
E-9	Increase the cost of transportation (Increase travel time costs)	0.785	11	0.800	7	0.886	4	0.815	9
E-10	Loss of road asset value	0.831	5	0.800	7	0.771	12	0.808	10
E-11	Increase the potential for road accidents (increase the risk of accidents or Worsen road safety)	0.800	10	0.767	11	0.829	9	0.800	11
E-12	Constrain access to essential services such as healthcare, education and emergency responses in the event of disasters	0.754	12	0.767	11	0.800	11	0.769	12
E-13	Negative impact on the environment (increase in CO2 emissions)	0.692	14	0.633	14	0.686	14	0.677	13
E-14	Isolate interconnection of towns and peoples	0.708	13	0.600	16	0.657	16	0.669	14
E-15	Increases the cost of farm inputs and production	0.631	16	0.667	13	0.714	13	0.662	15
E-16	Negative impacts on the physical health of citizens	0.646	15	0.633	14	0.686	14	0.654	16

4.5.1 Client's Point of View

As shown in Table 4.16, the respondents from the client-side ranked shorten the service/design life of the roads (RII=0.908) as the most frequent effect of poor road maintenance on road function; and reduce the riding comfort (RII=0.877) is ranked as the second frequent effect of poor road maintenance on road function. Similarly, these two problems are also got the top

ranks in both the respondents of consultants and contractors. This indicates that most of the respondents have the same opinion on these two effects.

Following these, increase vehicle operating costs and increase the rate of road deterioration are the third frequent effects of poor road maintenance on road function with the same value (RII =0.846). Loss of road asset value is the fifth frequent effect of poor road maintenance on road function with the same value of RII=0.831.

According to the respondents of this category, makes the cost of living unbearable for low-income-earners (RII=0.585) is ranked as the least frequent effect of poor road maintenance on road function.

4.5.2 Consultants' Point of View

The consultants' respondents have ranked reduce the riding comfort and shorten the service/design life of the roads as the most frequent effects of poor road maintenance on road function with the value of RII=0.933 and RII=0.900 respectively.

Following these, increase the rate of road deterioration is the third frequent effect of poor road maintenance on road function with the value of RII=0.867. Increase vehicle operating costs, deny the faster and better flow of transport services and dwarf economic development and growth of a country are the fourth frequent effects of poor road maintenance on road function with the same value (RII =0.833).

According to the respondents of this category, isolate interconnection of towns and peoples (RII=0.600) is ranked as the least frequent effect of poor road maintenance on road function.

4.5.3 Contractors' Point of View

Like the respondents from the consultants' side, the contractors' respondents have ranked reduce the riding comfort as the most frequent effect of poor road maintenance on road function with the value of RII=0.971 and decrease the road users' satisfaction ranked as the second frequent effect with the value of RII=0.943.

Following these, increase vehicle operating costs is the third frequent effect of poor road maintenance on road function with the value of RII=0.914. Deny the faster and better flow of transport services and increase the cost of transportation (increase travel time costs) are the fourth frequent effects of poor road maintenance on road function with the same value (RII =0.886).

According to the respondents of this category, isolate interconnection of towns and peoples (RII=0.657) is ranked as the least frequent effect of poor road maintenance on road function.

4.5.4 View of the Combined Result

As shown in Table 4.16, the combined RII and rank for the effect of poor road maintenance on road function were analyzed by taking the responses of the overall respondents from the three parties. Accordingly, out of sixteen (16) identified effects of poor road maintenance on road function, the top eleven (11) effects with RII value greater than 0.800 are discussed below and shown in Figure 4.11. Even though all the effects have the RII value of greater than 0.640, only the top 11 effects are selected for discussions in order to focus on the most frequent effects.

As shown in Figure 4.11, all of the top-ranked effects have the highest degree of frequency. Based on the result, all of the top-ranked effects such as reduce the riding comfort, shorten the service/design life of the roads, increase vehicle operating costs, increase the rate of road deterioration, decrease road users' satisfaction, deny the faster and better flow of transport services, dwarf economic development and growth of a country, initiates public complaint on the government, increase the cost of transportation (Increase travel time costs), loss of road asset value and increase the potential for road accidents (increase the risk of accidents or Worsen road safety) have the RII value of between 0.800 and 1.00, which shows that these effects have a very high degree of occurrence/frequency in road function. The RII and rank of each effect are shown in Figure 4.11 and Table 4.16.

All of these effects were selected as frequent and very frequent (always) by most of the respondents and therefore, they are the most frequently occurring effects on road function; hence, ERA and the concerned bodies shall consider them while undertaking any road maintenance in order to decrease the effects of poor road maintenance.

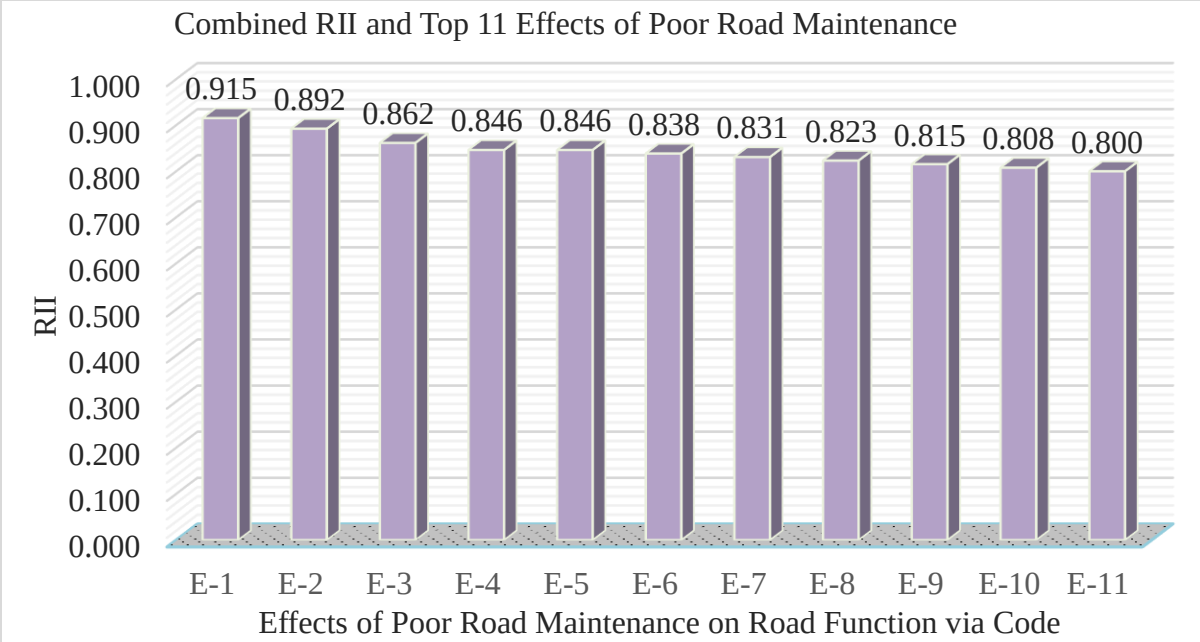

Figure 4.11: Combined RII and rank of the top 11 effects of poor road maintenance on road function.

4.5.5 Spearman's Correlation Between the Parties

In this section, respondents' responses were tested for correlation using Spearman rank correlation coefficients, to see the degree of agreement between two groups of respondents; these are client versus consultants, client versus contractors and consultants versus contractors on the other problems.

Table 4.17 shows Spearman's correlation between the client, consultant and contractor on the effects of poor road maintenance. From the correlation coefficient result, it can be concluded that there is a very strong relationship between the attitudes of the respondents in the client-consultant and consultant-contractor. It's also concluded that there is a strong relationship between the attitudes of the respondents in the client-contractor. This indicates that almost all of the respondents from the client, consultants and contractors have the same attitudes and perceptions towards the effects of poor road maintenance in road function.

Table 4.17: Spearman's correlation test on the ranking of the effects of poor road maintenance on road function.

Respondents	Spearman's Rank Correlation coefficient (r_s)	Relation of the Respondents
Client vs. Consultants	0.944	Very Strong
Client vs. Contractors	0.792	Strong
Consultants vs. Contractors	0.875	Very Strong

4.6 Interview with the Experts from Office of Road Fund

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 federal roads. As mentioned in section 4.2.3, the sole financier of road maintenance is the Office of Road Fund; hence, it is crucial to obtain their 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. Four interviewees having different positions under the aforementioned directorate were interviewed and their socio-demography is shown in Table 4.18.

Table 4.18: Socio-demography of Interviewees.

Position	**No. of Interviewee**	**Educational Status**	**Field of Specialization**	**Year of Exp. in road sector**	**Year of Exp. in Office of Road Fund**
Director	1	BSc	Civil Eng.	10 to 15 yrs.	0 to 5 yrs.
Team Leader	1	BSc	Civil Eng.	5 to 10 yrs.	5 to 10 yrs.
Senior Engineer	1	BSc	Civil Eng.	5 to 10 yrs.	0 to 5 yrs.
Engineer	1	BSc	CoTM	0 to 5 yrs.	0 to 5 yrs.
Total	**4**				

The aforementioned interviewees have been interviewed the following four questions based on the finding of the study (analyzed from the questionnaire, the responses were collected from the three main parties who have direct involvement in road maintenance projects such as a client, consultants and contractors) and their responses are also presented under each question.

1. The top three ranked client-related problems on road maintenance are procurement delay (A-1), insufficient road condition survey with lack of appropriate project prioritization mechanism (A-2) and slow decision-making process (A-3). Do you agree with this finding?

a. Yes, b. No; If your answer is Yes, what is the reason behind it? If your answer is No, what are the most significant client-related problems in view of the Office of Road Fund?

All of the interviewees have agreed and revealed the following reasons:

- ✓ Client (ERA) has given less attention to road maintenance.
- ✓ Client (ERA) still follows the traditional (conventional) approach in managing road maintenance.
- ✓ Client (ERA) has visible gaps in capacity building and research encouragement on road maintenance.

2. The top three ranked consultant-related problems on road maintenance are staff unavailability on the site (B-1), insufficient data collection and condition survey before road maintenance (B-2) and delay in decision making (B-3). Do you agree with this finding?

a. Yes, b. No; If your answer is Yes, what is the reason behind it? If your answer is No, what are the most significant consultant-related problems in view of the Office of Road Fund?

All of the interviewees have agreed and revealed the following reasons:

- ✓ The consultants do not offer real market price for service.
- ✓ Consultants' poor (weak) contract management system.
- ✓ The consultants give less attention to professional ethics.
- ✓ Client's poor monitoring and evaluation system on the consultants' performance.

3. The top three ranked contractor-related problems on road maintenance are shortage of equipment (C-1), equipment allocation/ management problems (C-2) and lack of acquiring new and recent technology equipment (C-3). Do you agree with this finding?

a. Yes, b. No; If your answer is Yes, what is the reason behind it? If your answer is No, what are the most significant contractor-related problems in view of the Office of Road Fund?

All of the interviewees have agreed and revealed the following reasons:

- ✓ Contractors' less dedication for their works.
- ✓ Consultants' poor (weak) project management.
- ✓ Owner of the company assigns the staff (professional) based on their interest (not based on the professional qualification).
- ✓ Contractors are not financially capable.

4. The top three ranked other problems on road maintenance are people in power have a little understanding on the effects of poor road maintenance (D-1), road maintenance is politically unattractive (D-2) and lack of interest by professionals to participate in road maintenance works (D-3). Do you agree with this finding?

a. Yes, b. No; If your answer is Yes, what is the reason behind it? If your answer is No, what are the most significant other problems in view of the Office of Road Fund?

All of the interviewees have agreed and revealed the following reasons:

- ✓ The Government's less attention for road maintenance.
- ✓ No well-organized policy and strategy for road maintenance.

5. The most frequently occurring effects of poor road maintenance on road function top three ranked other problems on road maintenance are reduce the riding comfort (E-1), shorten the service/design life of the roads (E-2), increase vehicle operating costs (E-3). Do you agree with this finding?

a. Yes, b. No; If your answer is No, what are the most frequently occurring effects in view of the Office of Road Fund?

All of the interviewees have agreed on this finding of the study.

4.7 Summary of the Findings

The problems in road maintenance are an inescapable fact in countries like Ethiopia. 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, the previous studies revealed that more than 70% of paved and 80% of unpaved federal roads in Ethiopia are not in good condition. This indicates that there are several problems hindering proper road maintenance to have well-conditioned road networks in Ethiopia.

While discussing about the problems in road maintenance, the parties involving in road maintenance have their own contributions. Hence, this study has considered it and categorized the problems based on their relation to the parties. It is obvious that there are some sources of problems in which the external parties (the parties other than the involved parties) take the responsibilities, such problems are named as the other problems in this research.

Accordingly, several problems were identified under each category based on the review of the literature and the discussions were made with the professionals in the sector. As the extent/magnitude or the degree of significance of the identified problems on the road maintenance varied, the analysis was done in order to identify the most significant problems under each category. Thus, the following top-ranked problems under each category are acknowledged as the most significant problems in road maintenance and need due attention from the concerned bodies.

A. Top ten (10) client-related problems in road maintenance.

1. Procurement delay
2. Insufficient road condition survey with lack of appropriate project prioritization mechanism
3. Slow decision-making process
4. Not managing the roads as a part of the market economy (roads are managed like a social service)
5. Not advocating Performance-Based Contracting System.
6. Lack of effective budget consumption (allocated budget is not consumed effectively)

7. Not advocating PPP in road maintenance
8. Weak management systems
9. High turnover of senior staff (leaving of senior staff)
10. Lack of capacity-building training for client staff, contractors and consultants involving in the maintenance

B. Top ten (10) consultant-related problems in road maintenance.

1. Staff unavailability on the site
2. Insufficient data collection and condition survey before road maintenance
3. Delay in decision making
4. No specialized consultants on the road maintenance
5. Inadequate maintenance experiences of consultants
6. Shortage of technically qualified personnel/staff
7. Inadequate maintenance experiences of consultant staff
8. Poor monitoring and controlling
9. High turnover of consultant staff (leaving of consultant staff)
10. Quality assurance/control problems

C. Top ten (10) contractor-related problems in road maintenance.

1. Shortage of equipment
2. Equipment allocation/management problems
3. Lack of acquiring new and recent technology equipment
4. Not managing resources efficiently and effectively
5. Incompatibility with new technology
6. Poor labor supply and productivity
7. Insolvencies and bankruptcies or cash flow problems
8. No specialized contractors on road maintenance
9. Inadequate experience of contractor's staff
10. Inefficient work methods
10. Poor maintenance contract management and project administration

D. Top seven (7) other problems in road maintenance.

1. People in power have a little understanding on the effects of poor road maintenance
2. Road maintenance is politically unattractive
3. Lack of interest by professionals to participate in road maintenance works
4. Working with maintenance is still looked up as a low-status occupation (undermining road maintenance works)
5. Road Maintenance has not been looked upon by universities as an intellectual subject
6. Inadequate financing arrangements/ insufficient budget for road maintenance
7. People in power have little/no knowledge /understanding of road maintenance

These acknowledged problems collectively lead to poor road maintenance on the federal roads, which have its effects on road function. In line with this, several effects of poor road maintenance on road function are identified based on the review of the literature and the discussions made with the professionals in the sector and the analysis has been done in order to identify the most frequent effects. Thus, the following top-ranked effects are acknowledged as the most frequently occurring effects of poor road maintenance on road function.

E. Top eleven (11) effects of poor road maintenance on road function.

1. Reduce the riding comfort
2. Shorten the service/design life of the roads
3. Increase vehicle operating costs
4. Increase the rate of road deterioration
5. Decrease road users' satisfaction
6. Deny the faster and better flow of transport services
7. Dwarf economic development and growth of a country
8. Initiates public complaint on the government
9. Increase the cost of transportation (Increase travel time costs)
10. Loss of road asset value
11. Increase the potential for road accidents (increase the risk of accidents or worsen road safety)

Based on the summary of the finding, the following specific and detailed recommendations are forwarded to the main stakeholders or parties to minimize the effects of the problems and to have proper road maintenance in the federal roads of Ethiopia.

I. Client (ERA) Should:

- Minimize the time taken for the procurement process and decision-making by establishing an appropriate mechanism like electronic procurement. This electronic procurement may take time for effective implementation; thus, it can be considered as a long-term solution. Whereas, as a short-term solution, giving sufficient emphasis for road maintenance projects like new construction and upgrading road projects is crucial; establishing separate engineering procurement directorate or team leader for road maintenance projects can minimize the time taken for the procurement process. Delays in executing maintenance due to different reasons including procurement delay can generally lead to increased severity of road deterioration (i.e., to poor or very poor conditions) and can eventually lead to a need for complete pavement rehabilitation or reconstruction in later years. This should be properly recognized by the client.
- Strengthen the management system like Pavement Management System, Bridge Management System, Axle Load Management System, etc. These systems are very important parts for proper road asset management; so, building the capacity by both required equipment like Hawkeye 2000, FWD, etc. and skilled human resource is very crucial. As a result, sufficient road condition surveys and appropriate project prioritization mechanism will be undertaken for federal roads of Ethiopia.
- Introduce, advocate and implement new concepts in a comprehensive scale on road maintenance management like a toll road system, Performance-Based Contracting System, PPP, etc.
- Use the allocated budget effectively and efficiently.
- Keep senior staff in the department by providing required incentives.
- Provide capacity-building based training packages, workshop and skill upgrading programs at the higher, middle and lower levels for client staff, contractors and consultants involving in road maintenance in order to upgrade and empower their skills.

- Support, aware, guide and enforce consultants, contractors and other concerned bodies to alleviate their problems and minimize their effects on road function.
- Develop and implement an effective strategy to minimize the effects of poor road maintenance on road function.

II. Consultants Should:

- Avail the full staff on the site throughout the project duration; so as to improve monitoring and controlling. It is well known that; the supervision consultants have agreed to residence their staff on the project site and the same is agreed and signed by the staff through the declaration of interest. Therefore, the consultants are fully liable for their agreed duties and should act accordingly.
- Conduct sufficient data collection and condition surveys before the contractors undertake road maintenance, as this is one of the consultant's major works in all road maintenance projects. The consultants should give full emphasis to this task as it majorly affects the contractors' performance and client's contract management in the aspect of the workload of the project.
- Minimize the time taken for the decision-making by establishing an appropriate mechanism.
- Specialize themselves in road maintenance; as a result, the consultant will have adequate road maintenance experiences and technically qualified staff with sufficient experience.
- Focus on quality assurance/control mechanism.
- Keep staff in the works by providing required incentives.

III. Contractors Should:

- Have all required equipment with proper allocation/ management mechanism on the site. As it is observed from sub-section 4.2.7 (Experience of Selected Road Maintenance Projects) and the finding of the study, shortage in the allocation of the equipment is one of the significant hindrances for proper road maintenance; considering this, the contractors should focus on providing adequate equipment for the projects. This can be managed by using the advance payment and his profit for

equipment purchasing, like other types of projects, so as the contractors can enhance themselves by the capacity and perform proper road maintenance.

- Acquire new and recent technology equipment and makes them compatible with technology to facilitate proper road maintenance. Thanks to today's technology and researchers, there are a lot of technology and new effective methodology developments in all aspects; so, the contractors should establish the technology seeker department under their company to update and acquire themselves in the recent technology development.
- Increase productivity by adopting an efficient work methodology and managing resources efficiently and effectively.
- Specialize themselves on road maintenance; as a result, the contractor will have adequate road maintenance experiences and well-experienced staff.
- Hire well-experienced staff in road maintenance for proper contract management and project administration.

IV. Government Should:

- Understand the road maintenance in general and effects of poor road maintenance on road function in specific in order to give due attention to road maintenance.
- Not only focus on political perspective but also focus on the socio-economic perspective of having well-conditioned road networks in the country.
- Facilitate sufficient budget/financial arrangements for road maintenance.
- Develop effective strategies and proper policy to enhance effective road maintenance.

V. TVET, Colleges and Universities Should:

- Not only give attention to road construction but also give due attention to road maintenance by considering its importance and incorporate it into the academic curriculum at undergraduate and graduate levels to produce competent and qualified professionals in a sector.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study points out the general approach of ERA towards the practice of road maintenance by identifying the problems of road maintenance. The study is not limited to the identification of the problems; it extends to analyze the degree of significance or magnitude of the identified problems on road maintenance. Besides, the study is focused on the assessment of the effects of poor road maintenance on road function.

Accordingly, several problems under four categories (namely client-related problems, consultant-related problems, contractor-related problems and other problems) and effects are identified based on the 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. Twenty (20) 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 (ERA). Among these problems, the top three problems such as procurement delay, insufficient road condition survey with lack of appropriate project prioritization mechanism and slow decision-making process need urgent and critical attention to enhance sustainable and effective road maintenance in Ethiopia.
2. Eighteen (18) consultant-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 consultants. Among these problems, the top three problems such as staff unavailability on the site, insufficient data collection and condition survey before road maintenance and delay in decision making need urgent and critical attention to enhance sustainable and effective road maintenance in Ethiopia.
3. Eighteen (18) contractor-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 contractors. Among these problems,

the top three problems such as shortage of equipment, equipment allocation/ management problems and lack of acquiring new and recent technology equipment need urgent and critical attention to enhance sustainable and effective road maintenance in Ethiopia.

4. eleven (11) other problems on road maintenance are identified and the top seven (7) 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 people in power have a little understanding on the effects of poor road maintenance, road maintenance is politically unattractive and lack of interest by professionals to participate in road maintenance works need urgent and critical attention to enhance sustainable and effective road maintenance in Ethiopia.
5. The least ranked problems under each category (ranked below 10) 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.
6. All the above-acknowledged problems collectively lead to poor road maintenance on the federal roads, which have its own effects on road function. In line with this, out of sixteen (16) identified effects, the top eleven (11) effects are acknowledged as the most frequently occurring effects of poor road maintenance on road function and need to be recognized from the concerned bodies.

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 effects of the problems and to have proper road maintenance in the federal roads of Ethiopia.

1. The client (ERA) is recommended to give all due attention towards the most significant (acknowledged) client-related problems in road maintenance while undertaking any road maintenance in order to alleviate the problems and minimize their effects. The client is also recommended to support, aware, guide and enforce the other stakeholders to give all due attention to their problems. Moreover, the client

should develop and implement an effective strategy to minimize the effects of poor road maintenance on road function.

2. The consultants are recommended to give all due attention towards the most significant (acknowledged) consultant-related problems in road maintenance while undertaking any road maintenance in order to alleviate the problems and minimize their effects.
3. 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 minimize their effects.
4. The government is recommended to recognize the importance of proper road maintenance in the socio-economic development of the country and should develop effective strategies and proper policies to enhance effective road maintenance in Ethiopia.
5. The author would like to suggest future research to be carried out on:
    - ✓ Implementation of Sustainable and Effective Road Maintenance in Ethiopia.
    - ✓ Enhancing the Financial Arrangement for Road Maintenance in Ethiopia.
    - ✓ Causes and Effects of Procurement Delay in Road Maintenance. (Please note: Procurement Delay is one of the identified problems in this study and it can be replaced by the other identified problems as per the interest of the researcher)

REFERENCES

1. AASHTO. (1987). *AASHTO maintenance manual 1987*. American Association of State Highway and Transportation Officials. https://books.google.com/books/about/AASHTO_Maintenance_Manual_1987.html?id=YkpGAAAAYAAJ
2. Addishiwot, T. (2019). *Experience of Output and Performance Based Road Contracting System in developing countries and future prospects in Ethiopian Federal Road Construction*. Addis Ababa Univeristy, Ethiopia.
3. Aldagheiri, M. (2009). The role of the transport road network in the economic development of Saudi Arabia. *WIT Transactions on the Built Environment*, *107*, 275–285. https://doi.org/10.2495/UT090251
4. Asian Development Bank. (2012). *Financing Road Construction and Maintenance after the Fuel Tax Reform*.
5. Biniyam, R. (2015). *Study of Performance Based Road Maintenance Contracting System for Ethiopian Federal Roads*. Addis Ababa, Ethiopia.
6. Boskovic, Z. V., & Tepsa, I. V. (2015). the Significance of Roads for the Development of Region. *4. Medunarodni Znanstveni Simpozij Gospodarstvo Istocne Hrvatske - Vizija I Razvoj*, 789–793.
7. COMCEC Coordination Office. (2016). *Enhancing Road Maintenance in the OIC Member States* (Issue March).
8. Donnges, C., Edmonds, G., & Johannessen, B. (2007). *Rural Road Maintenance: Sustaining the Benefits of Improved Access*.
9. Engström, R. (2016). The Roads' Role in the Freight Transport System. *Transportation Research Procedia*, *14*, 1443–1452. https://doi.org/10.1016/j.trpro.2016.05.217
10. ERA. (2013). *Technical Specification for Road Maintenance Works 2nd Edition*.
11. ERA. (2015). *The Road Sector Development Program Phase V*.
12. Fan, H. (2011). Rural road maintenance in China. *Transport and Communications Bulletin for Asia and the Pacific*, *81*(81), 52–68.
13. Gagblezu, M. S. (2018). *SUSTAINABLE MAINTENANCE GUIDELINES OF NON-TOLL ROADS IN SOUTH AFRICA*. Central University of Technology, Free State, South Africa.

14. Gunter J. Zietlow, D.-I. (2014). *Reform of Financing and Management of Road Maintenance*. International Road Federation (IRF). http://www.zietlow.com/docs/vortrweb.html
15. Hana, Y. (2017). *Economic Impact of Poor Pavement Maintenance in the City of Addis Ababa*. Addis Ababa Univeristy, Ethiopia.
16. Harvey, M. O. (2012). *Optimising Road Maintenance*.
17. Heggie I. G. (2004). Management and financing of roads: an agenda for reform. *World Bank Technical Paper*, *275*(275).
18. Heggie I, G. (1995). Commercializing africa's roads: Transforming the role of the public sector. *Africa Technical Department, The World Bank*, *15*(2), 167–184. https://doi.org/10.1080/01441649508716909
19. Jamaa Salih, Francis Edum-Fotwe, A. P. (2016). Investigating the Road Maintenance Performance in Developing Countries. *World Academy of Science, Engineering and Technology, International Journal of Civil and Environmental Engineering Vol:10, No:4*, *10*(4), 444–448.
20. JICA. (2003). *The Feasibility Study on the Improvement of National Road No.1 (Phnom Penh ~ Neak Loueng Section) in the Kingdom of Cambodia*.
21. Levik, K. (2016). *How to sell the message "Road maintenance is necessary" to decision makers*.
22. Malkanthi, S. N., Matsumoto, T., & Lanka, S. (2012). *Study of Effectiveness of Road Fund as a Solution for Maintenance Problem in Sri Lanka*. 86–90.
23. Mbara, T.C., M. Nyarirangwe, T. M. (2010). Challenges of Raising Road Maintenance Funds in Developing Countries: An Analysis of Road Tolling in Zimbabwe. *Journal of Transport and Supplay Chain Management*, 151–175.
24. Mostafa Hassan, M. (2018). Road Maintenance in Africa: Approaches and Perspectives. *E3S Web of Conferences*, *38*. https://doi.org/10.1051/e3sconf/20183801005
25. Naazie., A. N., Braimah, S. R., & Atindana, V. A. (2018). The Effects of Bad Roads on Transportation System in the Gushegu District of Northern Region of Ghana. *American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS)*, *40*(1), 168–185. http://www.asrjetsjournal.org/index.php/American_Scientific_Journal/article/view/3928/

1398

26. Office of the Road Fund. (2001). *Road Fund in Ethiopia: From Inception to Realization*.
27. Oronje, D. O., Rambo, C. M., & Odundo, P. A. (2014). *Flow of Funds for Sustainable Road Maintenance in Kenya*. (Vol. 5, Issue 1) [University of Nairobi, Kenya]. http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=90184889&site=ehost-live
28. Ross, D. (2018). The road maintenance backlog in South Africa. *SARF/IRF/PIARC Regional Conference for Africa*, 1–16.
29. Sally Burningham and Natalya Stankevich. (2005). Why road maintenance is important and how to get it done. *TRANSPORT NOTES, THE WORLD BANK, WASHINGTON, DC*, 94–102. https://doi.org/10.4324/9781351175746-8
30. Shrestha.P, P. P., & Shrestha.K, K. (2014). An Evaluation of Current Practices of Road Maintenance Contracting Methods. *Construction Research Congress 2014 ©ASCE*, 1408–1417. https://doi.org/10.1061/9780784413517.144
31. Shrestha.P, P., Shrestha.K, K., Said, A., & Lidder, M. (2017). Factors Affecting the Selection of In-House and Outsourcing Road Maintenance Methods and Assessment of Their Benefits. *Journal of Infrastructure Systems*, *23*(1), 06016001. https://doi.org/10.1061/(asce)is.1943-555x.0000315
32. Shrestha, P. P., Shrestha, K., & Lidder, M. (2017). Quality of Road Maintenance Work Performed by State Force versus Private Contractors in Nevada. *Practice Periodical on Structural Design and Construction*, *22*(4), 04017012. https://doi.org/10.1061/(asce)sc.1943-5576.0000326
33. Temesgen, G. (2016). *Asphalt Road Pavement Rehabilitation and Maintenance Case Study in Addis Ababa City Roads Authority*. Addis Ababa University, Ethopa.
34. Tourism Teacher. (2020). *Importance of road transport | Understanding tourism*. https://tourismteacher.com/importance-of-road-transport/
35. World Highways. (2015). *The importance of road maintenance | World Highways*. https://www.worldhighways.com/wh8/wh9/wh10/feature/importance-road-maintenance
36. Yetnayet, B. (2017). *Investigation of Road Asset Management Practices in Ethiopia (A Case Study: Addis Ababa City Roads Authority)* (Issue June). Addis Ababa University, Ethiopia.

APPENDICES

Appendix 1: Questionnaire

Questionnaire

On

Identification of Problems on Road Maintenance and Assessment of the Effects of Poor Road Maintenance on Road Function (In the case of Federal Roads of Ethiopia)

Dear respondent, this questionnaire aims to obtain necessary data for the partial fulfillment of an MSc thesis in Construction Technology and Management at Addis Ababa University. The objectives of this thesis are 1. To identify existing problems/challenges of road maintenance and to show their magnitudes and 2. To show the overall effects of poor road maintenance on road function in the case of Federal Roads of Ethiopia. Therefore, 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.

Ermias Eyob,
Post Graduate Student at A.A University, School of Civil and Environmental Engineering, Construction Technology and Management Stream.
Email: ermiaseyob675@gmail.com

Composition of the Questionnaire

This questionnaire consists three sections

Section I: *General information about company/organization and respondent*

Section II*: Questions about problems of road maintenance in the case of Federal Roads of Ethiopia*

Section III*: Questions about effects of poor road maintenance on road function*

Thank You for Your Corporations

Section I- General Information;

1. *State the name of organization/company*

   Name (optional): _____
2. *Which of the following best describes your organization/company*

   Client (ERA) ( ) Consultant ( ) Contractor ( )

3. *State the number of years of experience in which your company has in road construction industry (for consultants & contractors).*

   a. 0-5 ( ) b. 5-10 ( ) c. 10-15 ( ) d. more than 15 ( )
4. *State the number of years of experience in which your company has in road maintenance projects (for consultants & contractors).*

   a. 0-5 ( ) b. 5-10 ( ) c. 10-15 ( ) d. more than 15 ( )
5. *Gender: male ( ) Female ( )*
6. *Age: 18-30 ( ) 31-40 ( ) 41-50 ( ) 51-60 ( )*
7. *Level of education: Diploma ( ) Degree ( ) Master ( )*

   If other, please specify_____
8. *State your position in the organization/company*

   a. Resident Engineer ( ) b. Project manager ( )

   c. Counterpart Engineer ( ) d. Team Leader ( )

   e. Director ( ) If other, please specify_____
9. *State the number of years of experience you have in road construction industry.*

   a. 0-5 ( ) b. 5-10 ( ) c. 10-15 ( ) d. more than 15 ( )
10. *State the number of years of experience you have in road maintenance projects.*

    a. 0-5 ( ) b. 5-10 ( ) c. 10-15 ( ) d. more than 15 ( )
11. *State the number of road maintenance projects you have been involved*

    a. 1-3 ( ) b. 4-6 ( ) c. 7-9 ( ) d. more than 10 ( )

Section II

Problems of Road Maintenance In the case of Federal Roads of Ethiopia

Questions: *What is the magnitude/extent of the following identified problems in Road Maintenance (In the case of Federal Roads of Ethiopia)?*

- ✓ *Rate each problem according to the following rating scale by putting a thick mark for each problem stated below.*

(1) = Insignificant (3) = Averagely Significant (4) = Significant
(2) = Less Significant (5) = Very Significant

Categories	***Problems***	***1***	***2***	***3***	***4***	***5***
Client-related Problems	*Human resource constraints*					
	High turnover of senior staff (Leaving of senior staff)					
	Lack of qualified client staff					
	Lack of capacity-building training for client staff, contractors and consultants those involved in maintenance.					
	Not advocating Performance-Based Contracting system.					
	Not advocating Public Private Partnership (PPP) in road maintenance					
	Not managing the roads as part of the market economy (Roads are managed like a social service)					
	Insufficient road condition survey with lack of appropriate project prioritization mechanism					
	Difficult bureaucracy in client organization					
	Poor organization structures					
	Weak management systems					
	Poor communication with stakeholders					
	Lack of communication and coordination by owner it self					
	Lack of effective budget consumption (allocated budget is not consumed effectively)					
	Slow decision-making process					
	Procurement delay					
	Not hiring supervision consultants for all maintenance projects.					
	Change of plan and scope of the project					
	Repeated change order and variation order					
	Corruption					

Categories	Problems	1	2	3	4	5
Consultant-related problems	No specialized consultants on the road maintenance					
	Inadequate maintenance experiences of consultants					
	Inadequate maintenance experiences of consultant staff					
	High turnover of consultant staff (Leaving of consultant staff)					
	Staff unavailability on the site					
	Poorly qualified engineers and staff assigned to the project					
	Shortage of technically qualified personnel/staff					
	Poor communication and coordination of the consultant with other parties					
	Poor monitoring and controlling					
	Poor maintenance contract management and project administration					
	Quality assurance/control problems					
	Insufficient data collection and condition survey before road maintenance					
	No/little knowledge of maintenance specification					
	Delay in decision making					
	Late approval of test					
	Poor inspection and testing					
	Lack of interest by consultants to conduct laboratory and field tests					
	Corruption					

Categories	Problems	1	2	3	4	5
Contractor-related problems	No specialized contractors on road maintenance					
	Inadequate maintenance experience of contractors					
	Inadequate experience of contractor's staff					
	High turnover of contractor's staff (Leaving of contractor's staff)					
	Shortage of technically qualified personnel/staff					
	Poor communication and coordination of the contractor with other parties					
	Poor maintenance contract management and project administration					
	Poor site management					

Categories	Problems	1	2	3	4	5
	Inefficient work methods					
	Poor labor supply and productivity					
	Not managing resources efficiently and effectively					
	Poor demand and supply chain					
	Insolvencies and bankruptcies or cash flow problem					
	Shortage of equipment					
	Equipment allocation/management problems					
	Incompatibility with new technology					
	Lack of acquiring new and recent technology equipment					
	Corruption					

Categories	Problems	1	2	3	4	5
Other problems	*Road maintenance is politically unattractive*					
	People in power have little/no understanding of the importance of road maintenance					
	People in power have a little understanding on the effects of poor road maintenance					
	People in power have little/no knowledge /understanding of road maintenance					
	Inadequate financing arrangements/ insufficient budget for road maintenance.					
	The financial source for road maintenance is limited (only road fund)					
	Road users are not directly paying for roads					
	Working with maintenance is still looked up as a low-status occupation (undermining road maintenance works)					
	Lack of interest by professionals to participate in road maintenance works					
	Road Maintenance has not been looked upon by universities as an intellectual subject					
	Donors are not interested to fund road maintenance					
	Foreign contractors are not interested to participate in road maintenance					

Section III

Effects of Poor Road Maintenance on Road Function

Question: *which of the following effects of poor road maintenance on road function are frequently occurring?*

- ✓ *Rate each effect according to the following rating scale by putting a thick mark for each effect stated below.*

(1) = Never (2) = Rarely (3) = Occasionally (4) = Frequently (5) = Always

Effects	***1***	***2***	***3***	***4***	***5***
Shorten the service/design life of the roads					
Loss of road asset value					
Increase the rate of road deterioration					
Increase the cost of transportation (Increase travel time costs)					
Deny the faster and better flow of transport services					
Dwarf economic development and growth of a country					
Isolate interconnection of towns and peoples					
Constrain access to essential services such as healthcare, education and emergency responses in the event of disasters					
Increase vehicle operating costs					
Increase the potential for road accidents (increase the risk of accidents or Worsen road safety)					
Reduce the riding comfort					
Decrease road users' satisfaction					
Negative impacts on the physical health of citizens					
Increases the cost of farm inputs and production					
Makes the cost of living unbearable for low income-earners					
Initiates public complaint on the government					
Initiates unnecessary interference of the political leaders in the sector					
Negative impact on the environment (increase in CO2 emissions)					

Thank you for your time

Appendix 2: Interview

Interview Schedule

Introduction

This interview schedule is prepared to obtain information from key experts of the Office of Road Fund through semi-structured questions. The information was required for the academic research entitled ***"Identification of Problems on Road Maintenance and Assessment of the Effects of Poor Road Maintenance on Road Function (In case of Federal Roads of Ethiopia)"*** which is being conducted as partial fulfillment of MSc in Construction Technology and Management at Addis Ababa University. The objectives of this thesis are 1. To examine the current road maintenance practices of ERA, 2. To identify existing problems/challenges of road maintenance and to show their magnitudes and 3. To show the overall effects of poor road maintenance on road function in the case of federal roads of Ethiopia.

Your response, in this regard, is highly valuable and contributory to the outcome of the research.

All feedback will be kept strictly confidential, and utilized for this academic research only.

Ermias Eyob,
Post Graduate Student at A.A University, School of Civil and Environmental Engineering, Construction Technology and Management Stream.
Email: ermiaseyob675@gmail.com

Composition of the Interview

This interview consists two sections

Section I: *General information about the interviewees*

Section II*: Questions based on the finding of study*

Thank You for Your Corporations

I. General Profile of the Interviewees

1.1 Name_____

1.2 Position_____

1.3 Organization_____

1.4 Address_____

1.5 Educational status?

a. BSc b. MSc c. If other, please specify _____

1.6 What is your field of specialization?

a. Civil Engineering

b. Construction Technology and Management.

c. Highway Engineering

d. Geotechnical Engineering

e. If others, please specify _____

1.7 How long have you worked in the road sector?

a. 0-5 ( ) b. 5-10 ( ) c. 10-15 ( ) d. more than 15 ( )

1.8 How long have you worked with your current organization (Office of Road Fund)?

a. 0-5 ( ) b. 5-10 ( ) c. 10-15 ( ) d. more than 15 ( )

II. Questions Based on the Finding of Study

2. Data obtained from ERA reveals that the allocated budget by RF for road maintenance of federal roads is by far less than the requested budget (maintenance need of the roads), the average percentage allocation for the past ten years is 47.6%. In relation to this data, please answer the following questions

2.1. In what mechanism does the Office of Road Fund allocate the budget.

a. By conducting the road condition of the country (maintenance need assessment)

b. By fixed proportion (distributing the regular budget through the fixed proportion)

c. If other, please specify; _____

2.2 what are the reasons behind such budget shortfall?

_____

_____

_____

3. Please provide your opinion on the following finding of the study (analyzed from the questionnaire, the responses were collected from the three main parties who have direct involvement on road maintenance projects such as client, consultants and contractors).

3.1. The top three ranked client-related problems on road maintenance are procurement delay (A-1), insufficient road condition survey with lack of appropriate project prioritization mechanism (A-2) and slow decision-making process (A-3). Do you agree with this finding?

a. Yes b. No

If your answer is Yes, what is the reason behind it?

_____

_____

_____.

If your answer is No, what are the most significant client-related problems in view of the Office of Road Fund?

_____

_____

_____.

3.2. The top three ranked consultant-related problems on road maintenance are staff unavailability on the site (B-1), insufficient data collection and condition survey before road maintenance (B-2) and delay in decision making (B-3). Do you agree with this finding?

a. Yes b. No

If your answer is Yes, what is the reason behind it?

_____

_____

_____.

If your answer is No, what are the most significant consultant-related problems in view of the Office of Road Fund?

_____

_____

_____.

3.3. The top three ranked contractor-related problems on road maintenance are shortage of equipment (C-1), equipment allocation/ management problems (C-2) and lack of acquiring new and recent technology equipment (C-3). Do you agree with this finding?

a. Yes b. No

If your answer is Yes, what is the reason behind it?

_____

_____

_____.

If your answer is No, what are the most significant contractor-related problems in view of the Office of Road Fund?

_____

_____

_____.

3.4. The top three ranked other problems on road maintenance are people in power have a little understanding on the effects of poor road maintenance (D-1), road maintenance is politically unattractive (D-2) and lack of interest by professionals to participate in road maintenance works (D-3). Do you agree with this finding?

a. Yes b. No

If your answer is Yes, what is the reason behind it?

_____

_____

_____.

If your answer is No, what are the most significant other problems in view of the Office of Road Fund?

_____

_____

_____.

3.5. The most frequently occurring effects of poor road maintenance on road function top three ranked other problems on road maintenance are reduce the riding comfort (E-1), shorten the service/design life of the roads (E-2), increase vehicle operating costs (E-3). Do you agree with this finding?

a. Yes b. No

If your answer is No, what are the most frequently occurring effects in view of the Office of Road Fund?

_____

_____

_____.

Appendix 3: List of Projects Considered for Questionnaire

List of projects with its detail information considered for questionnaire

I. No	Project Name	Length (Km)	Contract Administering Directorate /Client	Contractor Name	Consultant Name	Works Contractual data					Progress (%) as of Oct 2020
						Contract Amount (ETB)		Contract Signing Date	Commencement Date	Completion Date	
						Original	Revised				
1	Shekhussen-Micheta Lot-1 Periodic Maintenance	60	Shashemene RNSMBD	Doche Deme GC	Classic consulting Engineers PLC	28,982,187.88		28- Jan-20	1-Apr-20	1-Apr-21	90
2	DoloOdo Junction – Doloby-Hargele Lot-1 Periodic Maintenance	60		Hoha Engineering PLC		39,158,302.24		03- Feb-20	3-Mar-20	3-Mar-21	85
3	DoloOdo Junction – Doloby-Hargele Lot-2 Periodic Maintenance	60		MEDCON Engineering and Construction PLC		39,991,668.23		03- Feb-20	3-Mar-20	3-Mar-21	50
4	Bokolomayo – Sarole – DoloOdo Periodic Maintenance	86		MEDCON Engineering and Construction PLC		51,378,560.94		03- Feb-20	3-Mar-20	Sep, 2021	50
5	Gedo-Nekemte-Mekenejo Routine Term Maintenance	267	RNMCD	Saylem Construction PLC	Nekemete RNSMD	89,676,546.64		6-Nov-17	15-Nov-17	2-May-20	93

I. No	Project Name	Length (Km)	Contract Administering Directorate /Client	Contractor Name	Consultant Name	Works Contractual data					Progress (%) as of Oct 2020
						Contract Amount (ETB)		Contract Signing Date	Commencement Date	Completion Date	
						Original	Revised				
6	Kebridher - Gode -Hargele Routine Term Mainteance	459	Diredawa RNSMBD	3M Engineering & Construction in JV with Africawit Construction plc.	ELDA Engineering Consultants in JV with Gogot consulting Engineers	64,931,045.24	68,666,989.14	29-Jun-18	28-Aug-18	31-Oct-20	53
7	Jijiga Section Routine Maintenance	290		Ecosafe construction		49,990,884.10		17-Mar-17	19-Apr-17	20-Apr-19	100
8	Bako Section Routine Term Maintenance	136	Nekemte RNSMBD	Crafts Construction PLC	Birhan Construction Design Consultants plc	99,253,394.26		16-Feb-17	9-Mar-17	6-Jun-20	50
9	Nedjo - Jarso - Shimeltoke Periodic Maintenance	65		Tewodros Simeneh General Contractor		45,805,859.30		20-Feb-17	3-Sep-17	3-Sep-19	100
10	Sherkole- Blue Nile Periodic Maintenance Project	80		Tekrom Construction		48,650,237.10		8-Jan-18	8-Feb-18	8-Feb-20	100

I. No	Project Name	Length (Km)	Contract Administering Directorate /Client	Contractor Name	Consultant Name	Works Contractual data					Progress (%) as of Oct 2020
						Contract Amount (ETB)		Contract Signing Date	Commencement Date	Completion Date	
						Original	Revised				
11	Metu Section Routine Maintenance	183	Jimma RNSMBD	Oromia Roads Construction Enterprise	White knight Consulting Engineers PLC	27,794,467.20		12-Jan-18	1-Feb-18	31-Jul-20	82
12	Metu- Alge Periodic Maintenance Project	50		Mengesha Abera Trading PLC		70,597,698.05	71,334,101.13	8-Jan-18	26-Jan-18	19-Mar-20	100
13	Woito-Erbore-Turmi Periodic maintenance	117	Sodo RNSMBD	Mesfin Solomon Construction	ELDA Engineering Consultants in JV with Gogot consulting Engineers	86,202,381.95	103,826,624.75	8-Jan-18	22-Jan-18	19-Jun-20	100
14	Tsilary-Sekota Periodic Maintenance	52	Adigrat RNSMBD	Kibrom GC	Beles Consulting Plc.	16,649,715.53		31-Jan-17	28-Feb-17	28-Feb-19	100
15	Seraba-Delegi-Shawera(0-84km) Periodic Maintenance	84	Gonder RNSMBD	Yonatan GC	Eng. Zewdie Eskindir & Co. Plc in sub Ensirad civil system	43,028,679.15		31-Jan-17	28-Feb-17	28-Feb-19	100

I. No	Project Name	Length (Km)	Contract Administering Directorate /Client	Contractor Name	Consultant Name	Works Contractual data					Progress (%) as of Oct 2020
						Contract Amount (ETB)		Contract Signing Date	Commencement Date	Completion Date	
						Original	Revised				
16	Ginchi- Bussa-Tulubolo Periodic maintenance	48	Alemgena RNSMBD	Tiks Construction in JV with FAL General Contractor	Classic consulting Engineers PLC	19,826,753.73		6-Nov-17	15-Nov-17	15-Nov-19	100
17	Huruta Section Routine Term Mainteance	305		Man General Contractor		30,687,384.48		6-Nov-17	15-Nov-17	15-Nov-19	100
18	Endibir Section Routine Term Mainteance	235		Hoha Engineering		29,006,734.49		6-Nov-17	15-Nov-17	15-Nov-19	100
19	Dera-Mechara Routine Term Maintenance	324		Senan Construction		72,909,773.69		6-Nov-17	18-Jan-18	18-Jan-20	100
20	Tenta Section Routine Term Mainteance	328	Combolcha RNSMBD	Yonatan GC	ConAbe Consult Plc	37,680,699.29		20-Feb-17	13-Mar-17	13-Mar-19	100
21	Delomena-Bidere Periodic Maintenance	73	RNMCD	Hoha Engineering	Shashemane RNSMBD	27,597,813.09		20-Feb-17	9-Mar-17	10-Mar-19	100