



JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT OF ROAD ASSET MANAGEMENT PRACTICES AND ITS
CHALLENGES: A CASE OF ETHIOPIAN ROADS ADMINISTRATION

A Thesis submitted to School of Graduate Studies, Jimma University, Jimma Institute of Technology, Faculty of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree Master of Science in Construction Engineering and Management.

By:
JENBERU TADESSE MINDAYE

March 2025
Jimma, Ethiopia

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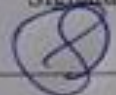
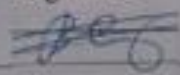
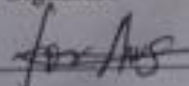

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ASSESSMENT TO ROAD ASSET MANAGEMENT PRACTICES AND
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ADMINISTRATION

JENBERU TADESSE MINDAYE

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ABSTRACT

This research explores the Assessment of Road Asset Management Practices and Challenges within the Ethiopian Roads Administration (ERA). Roads are pivotal to Ethiopia's socio-economic growth, connecting remote areas and enabling the movement of goods and people. Despite significant improvements in road density and network expansion since the inception of the Road Sector Development Program (RSDP) in 1997, challenges persist in asset management practice, maintenance, and sustainability.

The study utilized both qualitative and quantitative approaches, incorporating questionnaire surveys, interviews, and desk reviews, aimed at professionals engaged in road asset management of ERA. The study findings reveals that, ERA's approach to road asset management practices integrates methods and approaches such as own-force Road maintenance contractor, private contractor engagements, axle load control systems, and periodic traffic surveys. These methods and approaches collectively aim to ensure the sustainability and efficiency in Road asset management practices of ERA for the road network. Although some modern technological tools such as automated data collection systems for Road condition assessment and axle load control have been introduced in ERA's Road asset management practices, their integration remains limited. The study findings also highlighted that significant challenges including financial constraints, gaps in technological adoption in Road asset management, limited technical and resource capacity of ownforce road maintenance contractor, and inadequate stakeholder engagement, Road asset management components challenges and weak regulatory enforcement (absence of Road policy), which collectively undermine the effectiveness of ERA's Road asset management practices.

Finally it's recommended that ERA shall works on adoption of centralized data management systems, enhanced use of automated technologies in road asset management practice, enhanced funding mechanisms and structured capacity-building initiatives for ownforce road maintenance contractor and professional works on road asset management. Improving these areas will enable ERA to optimize resource allocation, sustain road assets, and contribute significantly to country's economic progress.

Keywords: *Road Asset Management, Road Asset Management Practice, ERA, Decision Making Process (Level).*

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ABBREVIATION or ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
AM	Asset Management
BMS	Bridge Management System
ETB	Ethiopian Birr
ERA	Ethiopian Roads Administration
FDOT	Florida Department of Transportation
FHWA	Federal Highway Authority
KM	Kilometer
MMS	Maintenance Management System
MRP	Maintenance Rating Program
NCHRP	National Cooperative Highway Research Program
OECD	Organization for Economic Co-Operation and Development
PMS	Pavement Management System
RAS	Robotics and Autonomous System
RMI	Road Maintenance Initiative
RIAMS	Road Infrastructure Asset Management System
RRA	Regional Roads Authority
RSDP	Road Sector Development Program
SPSS	Statistic Package for Social Science
TAM	Transport Asset Management
WRO	Woreda Roads Office

CHAPTER 1

1. INTRODUCTION

1.1. Background of the study

Transportation is one of the fundamental infrastructures to the development and operation of any society. It permits geographically distant resources to become accessible, connect people, and exchange technology and goods needed in different places. This makes it evident that the economic growth of any society in any part of the world is directly related to the availability of transportation. Among others, road transport network plays a crucial role for developing countries because providing other advanced means of transportation is expensive.

A report of the Road Sector Development Program (RSDP) of the Ethiopian Roads Administration shows, Ethiopia is the second most populous country in Sub-Saharan Africa, which is well endowed with natural resources, with 60% of its total land area estimated to be potentially arable, but has had a road density amongst the lowest in Africa and other developing countries. Besides the low road density and high road accident rates, deteriorating roads have become a major economic problem, not only in Ethiopia but also in Sub-Saharan Africa as a whole (Ethiopian Roads Administration, 2022).

Recognizing the importance of road transport in supporting social and economic growth and poverty alleviation objectives, the Government of Ethiopia has increased its emphasis on improving the quality and size of the road infrastructure. To this end, in 1951, the Ethiopian Roads Authority, currently the Ethiopian Roads administration, was established; during the same year, the entire road network amounted to 6,400 km. In addition, E.R.A., with the support of other development partners, launched the Road Sector Development Program (RSDP) in 1997 to tackle the shortcomings in the road sector and complement other sector development programs. This program provides a comprehensive approach to integrating the implementation of key road investments with major policy and institutional reforms.

After the establishment of RSDP in Ethiopia, the transport infrastructure average density of the road network increased from 24.1 KM per 1000 sq. km in 1997 to 135.8 KM per 1000 sq. km in 2021 and 0.46 KM per 1000 population in 1997 to 1.42 KM per 1000 population in 2021 which shows that an improvement in the Road Network of the country's from 26,550 KM in 1997 to 155,830 KM in 2021 (average annual growth of 7.9 percent). However, although considerable efforts have been made to expand the road network over the past few decades, the density still is below the average (Urban and Development, E.R.A. 24 years RSDP Assessment Report, 2022).

Besides Roads construction, Road asset management is another crucial issue in Ethiopia. Road asset management is a systematic process of cost-effectively maintaining, upgrading, and operating physical assets. It harmonizes engineering and economic principles to make beneficial business practices. In order to reduce life cycle costs and contribute to the effectiveness of organizations, it is essential to manage the physical asset through its acquisition, operation, maintenance, and disposal phases. Therefore, asset Management, referring to physical equipment and structures, can be best described on a high level as the management of these physical assets through their entire life cycle (Mollentze, 2005).

Transportation Asset Management (T.A.M.) is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life cycle. It focuses on business and engineering practices for resource allocation and utilization, aiming for better decision-making based on quality information and well-defined objectives (Citation, 2013).

The attractiveness of asset management is that it considers all important aspects that need to be managed in the life cycle of an asset, right from inception to disposal. One important phase within an asset's life cycle is the operational and maintenance phase (O&M). Studies indicate that depending on the business context, operation, and maintenance constitute between 15 and 70 % of the total cost of ownership (Haider and Koronios, 2013).

It is well known that in Ethiopia, Ethiopian Roads Administration plays a great role in Road asset management to sustain the road transport sector in good condition throughout the country. However, road asset management increases Road users' efficiency, comfort, reliability, and productivity when effectively managed. Hence, the Ethiopian Roads Administration established Road asset Management Directorate under different departments for efficient Road asset management via its branches directorate and Road Maintenance District Contractors throughout the country. Therefore, studying of Ethiopian Roads Administration (E.R.A.) Road asset management practice and its current challenge is crucial for the Road sector development of the country.

1.2. Statement of the Problem

Despite the critical role of road asset management in supporting economic growth and social development, the assessment of road asset management practices and its challenges within the Ethiopian Roads Administration is limited. There is a lack of comprehensive research that examines the effectiveness of current practices, evaluates the challenges faced by ERA, and provides insights for enhancing road asset management strategies. This knowledge gap hinders

the development of evidence-based policies, resource allocation, and capacity building initiatives required to optimize road infrastructure performance and sustainability in Ethiopia.

Even though the Road sector infrastructure in Ethiopia shows increment, due to a lack of care, poor management, and maintenance, road assets are deteriorated and damaged (Kenea *et al.*, 2021).

The road infrastructure of Ethiopia has deteriorated and faced high conservation costs on the aging transportation trace similar that it was a serious forestallment to the sweats of the Government of Ethiopia for reviving the frugality toward achieving sustained poverty reduction by perfecting access links between product centers and requests (Ayalew, Meharie and Worku, 2022).

Most of the research studies done in Ethiopian Road sectors are mainly related to Road maintenance practices rather than Road asset management practices (Ayalew, Meharie and Worku, 2022), (Kenea *et al.*, 2021) (Daniel Agidew, 2017), (Temesgen, 2018), (Belete Werkinch and Arega Demissie, 2019).

Despite the growing recognition of the importance of technology in enhancing road asset management, the integration of advanced technologies tools, such as Geographic Information Systems (GIS) and automated data collection systems, are essential to increase the ability to efficiently monitor, maintain, and optimize road assets. The lack of this technological integration affect decision-making processes and also limit the capacity to predict and prevent road asset deterioration effectively. Studies, such as those by Yetnayet Bihon (2017), highlight the absence of integrated management systems and the challenges in implementing technology-driven solutions in Ethiopia's road sector (Semunigus, 2020). Addressing these gaps is crucial for improving the sustainability and performance of road infrastructure in the country.

Therefore, there is a pressing need to conduct a research study that assesses the road asset management practices and challenges within the Ethiopian Roads Administration. By addressing this knowledge gap, the research aims to contribute to the understanding of the current state of road asset management practices, identify the specific challenges faced by ERA, and propose recommendations to enhance the effecitiveness and efficiency of road asset management. The findings of this research will provide valuable insights for policymakers, practitioners, and stakeholders, enabling them to make informed decisions and allocate resources strategically to improve the management and maintenance of the Ethiopian road network.

1.3. Research Questions

The research is designed to answer the following questions in relation to the respective research objectives.

1. What are the existing methods and approaches used by the Ethiopian Roads Administration in road asset management practice?
2. To what extent has technology been integrated into the management of road assets, such as pavements and bridges, within the Ethiopian Roads Administration?
3. What are the current challenges affecting the effectiveness of road asset management practices in the Ethiopian Roads Administration?

1.4. Objectives of the Research

1.4.1. General Objective of the research

The general objective of this study is to assess the road asset management practice and its challenges in the case of Ethiopian Roads Administration.

1.4.2. The Specific Objective of the research

Specifically, the Research will address the following objectives:

1. To examine the existing methods and approaches utilized in road asset management that practiced by the Ethiopian Roads Administration;
2. To assess the extent of technological advancement/integration in managing key road asset components, including pavements and bridges, within the Ethiopian Roads Administration;
3. To identify and analyze the current challenges hindering effective road asset management practices in the Ethiopian Roads Administration;

1.5. Scope of the study

This study focuses on assessing the road asset management practices of the Ethiopian Roads Administration (ERA) specifically within the operation and maintenance phase. The research is limited to the road network managed by ERA., excluding the road asset management practices of Regional Roads Authorities (RRAs), and Municipalities due to time and budget constraints.

1.6. Limitations of the study

- Financial Constraints: Budget limitations affected the scope of data collection and analysis, potentially limiting the depth of the study.

- Time Constraint: Time restricts a period for data collection and analysis
- Evolving Practices and Policies: Since the study only reflects data up to a certain period, it may not fully capture recent updates or improvements in road asset management practices and policies introduced by ERA after the data collection period.

1.7. Significance of the study

The findings of this studies will help:

- Road Asset Administrator to evaluate the existing road asset management practices and identify the challenges faced by road infrastructure administrators (ERA).
- Furthermore, it will help infrastructure managers to investigate the best road asset management method during Roads Asset life cycle.
- The study's findings will inform ERA (i.e. Road Asset Administrator) and stakeholders about the Ethiopian Roads Administration's road asset management practices.
- In addition, it will be of enormous significance for the stakeholders to consider the area's peculiar circumstances in developing and implementing case-specific intervention plans.

1.8. Structure of the Study (Research)

This research consists of five main chapters as follows:

1. Chapter one: Introduction: that shows the background of the study, statement of the problem, objectives of Research, research questions, scope and significance of the Research.
2. Chapter two: Literature review: the chapter shows a details review of concepts and definitions to identify the practice of road asset management and its challenging factors.
3. Chapter three: Research methodology: this chapter shows the methodology used in this Research to achieve the required objectives to answer the research questions.
4. Chapter Four: Result and Discussion : This chapter presents discussion and analysis part of the research for collected data via different methodology
5. Chapter Five: Conclusion and Recommendation: This part mainly deals with the final output of the research for assessment of Road Asset Management practices and its challenges of Ethiopian Roads Administration.

CHAPTER 2

2. LITERATURE REVIEW

2.1. Concepts of Road Asset Management

The Concept of Asset Management (AM) science and practice has been introduced previously. Agencies in Europe, New Zealand, Australia, and Canada started in the late 1980s and early 1990s. During the last decade of the 20th century, there has been a slow but consistent movement towards a more holistic approach to managing these assets. Transportation agencies in the United States (U.S.) and worldwide have begun acknowledging the merits of a more comprehensive methodology for managing their infrastructure. This holistic way of dealing with the management of transportation assets, coupled with more "business-like" objectives, has led to what is today commonly known as Asset Management (Semunigus, 2020).

In 1996, AASHTO and FHWA hosted an superintendent- position AM forum in Washington, D.C., to introduce AM to the state transportation agencies. During this event, attended by AASHTO leadership, FHWA, state departments of transportation, private industry, utility companies, quasi-governmental organizations, and the research and development community, Suppliers shared their experience and expertise in improving the quality of additive manufacturing. The results are documented in FHWA's Asset Management: Advancing the State of the Art in the 21st Century through Public-Private Dialogue (1997), which describes the goals, attributes, and utility of additive manufacturing. In addition, the seminar focused on integrating decision-making beyond pavements and bridges (Cowe Falls *et al.*, 2001).

The concept of asset management is receiving substantial attention and interest from many transportation agencies, including the Transportation Association of Canada (T.A.C.) and FHWA those published asset management primers. In addition, a senior-level AASHTO/FHWA workshop on asset management was held in December 1999 in Phoenix (Cowe Falls *et al.*, 2001). The basic context for asset management lies in the mission statements of transportation agencies. A review of these statements indicates that almost all are directed at providing safe, reliable, and efficient transportation. Other terms or goals are "desirable driving standards,"; performance standards involving "pavement smoothness and riding comfort,"; "foster a competitive business environment supported by a safe, efficient, and accessible transportation network,"; ensuring "appropriate levels of quality and accessibility"; and "minimize the long-term costs of preserving the highway system (Cowe Falls *et al.*, 2001)."

Among the reasons for the interest in asset management is the perception that applying corporate business principles, including proper financial and management accounting methods, will lead to more efficient and cost-effective transportation program delivery. However, of course, this must be reconciled with the profit motives of the private sector versus the plethora of objectives and demands facing public-sector agencies. Another dimension is the existing management systems for pavements, bridges, traffic congestion, safety, etc. While it is generally recognized that these component systems must be integrated into an overall asset management strategy, actually carrying out that integration has yet to occur to any extent (Cowe Falls *et al.*, 2001).

2.2. Basic Definitions of Road Asset Management Terminologies

The definitions of 'Asset management' and 'Transport Asset management' adopted by many road organizations have changed. The majority of these definitions have been limited in scope and have focused on the life cycle management of physical infrastructures (Gunarathna, Hassan, and Lamborn, 2014). They reflect an emphasis on physical infrastructure but vary in that some consider physical assets provision, operation, and disposal in addition to maintenance and upgrading. However, generally, all focus on achieving user and community needs, expected Level of Services (L.O.S.), and safer roads. Several definitions of transport-specific asset management are shown in the table below (Denton, P. and McIlroy, 2018).

Table 2-1 Definitions of Transportation Asset Management by a different organization

Organization/ Author	Definition
National Cooperative Highway Research Program (NCHRP) (2002)	“Transportation Asset Management is a strategic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life-cycle. It makes a speciality of enterprise and engineering practices for useful resource allocation and utilization, with the goal of higher selection making primarily based totally upon nice data and nicely described objectives.”
U.S. Department of Transportation (USDOT) (1999)	Asset Management is a systematic process of cost-effectively maintaining, upgrading, and operating physical assets. It combines engineering principles with sound business practices and economic theory and provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling short and long-range planning."
Count Surveyors Society (2004)	“Asset management is a strategic approach that identifies the optimal allocation of resources for the management, operation, preservation and enhancement of the highway infrastructure to meet the needs of current and future customers.”

Organization for Economic Cooperation and Development (OECD) (2001)	““A systematic manner of maintaining, upgrading and running assets, combining engineering concepts with sound commercial enterprise exercise and monetary rationale, and imparting gear to facilitate a greater prepared and bendy technique to creating the selections essential to reap the public’s expectations.”
Institute of Public works Engineering Austria (2011)	"To meet a required level of service, most cost-effectively, through managing assets for present and future customers."
Bitner & Rosen (2004)	"T.A.M. is a systematic process of operating, maintaining, and upgrading physical assets cost-effectively. It combines engineering and mathematical analysis with sound business practice and economic theory."

All these definitions in Table 2.1 above state that asset management is systematic, strategic, and customer-focused. These themes are particularly relevant to highway maintenance that justify the large budgets allocation so that a safe and serviceable network can be provided (Dongen, 2015)

Moreover, in the case of highway maintenance in different world countries such as Australia, Canada, England, and New Zealand, (Dongen, 2015) found that an organizational culture and a decision-making process is a critical challenges to asset management for transportation programs and successful asset management requires top-level commitment.

Another related terminology to Road asset management is the Road Infrastructure Asset Management System (RIAMS), a systematic process of maintaining, upgrading, and operating different components of road infrastructures in the most cost-effective manner. It provides a concrete foundation to monitor the performance periodically and to optimize the maintenance and rehabilitation (M&R) actions through cost-effective management, programming, and resource allocation decisions (Amin and Amador, 2014). The RIAMS can be explained in different terms such as ‘ensure desirable driving standards’, ‘maintain performance standards involving pavement smoothness and riding comfort’, ‘foster a competitive business environment supported by a safe, efficient, and accessible transportation network’, ‘ensure appropriate levels of quality and accessibility’, and ‘minimize the long-term costs of preserving the highway system’, and so on(Amin and Amador, 2014).

Besides the above definitions, some scholars also described Total Asset Management as a comprehensive and structured planning process for developing capital and recurrent programs and budgets that focus on customer and community needs, provide quality services, and a commitment to excellence to ensure that assets remain productive (Cowe Falls *et al.*, 2001).

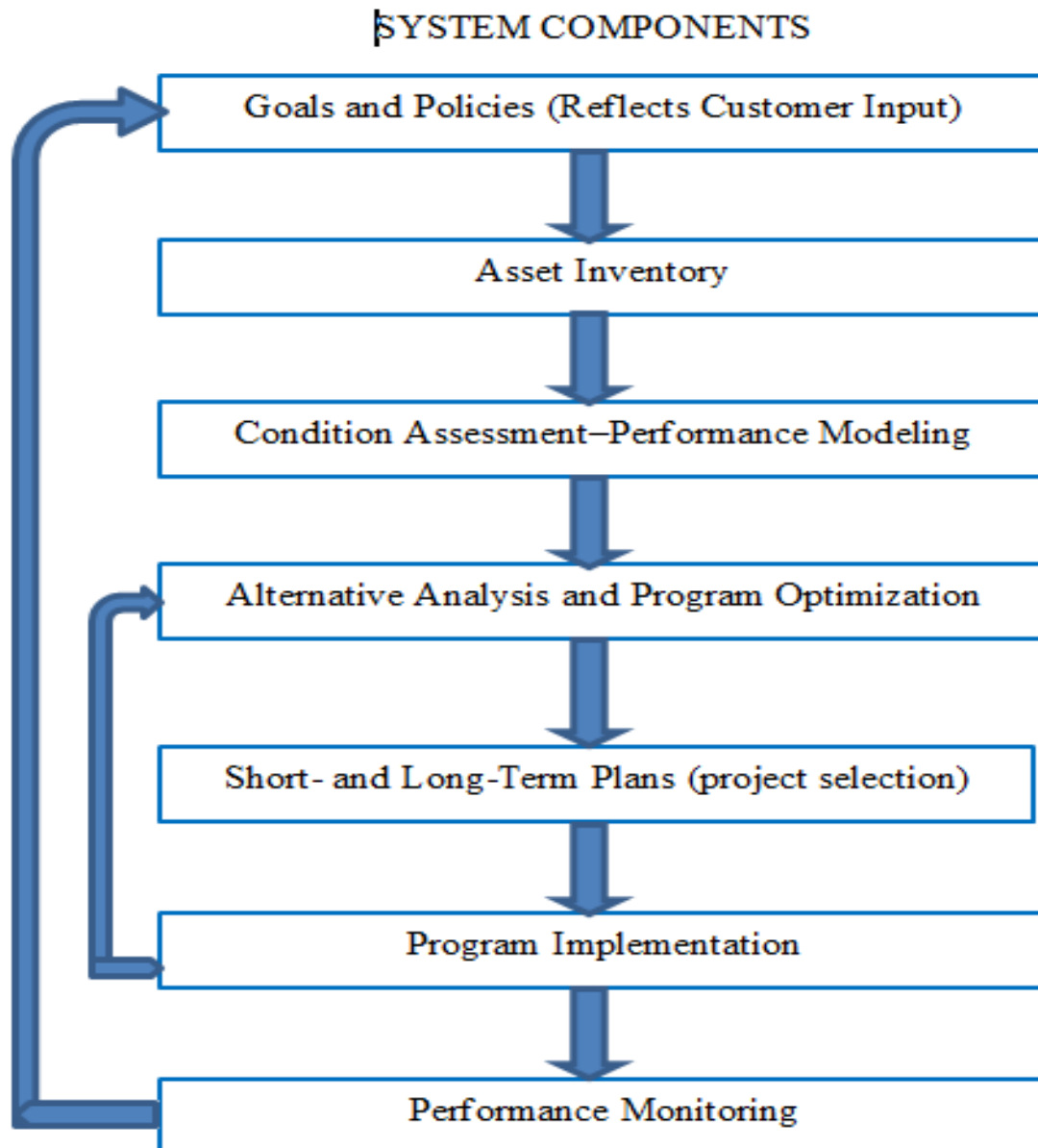
2.3. Transportation Asset Management Systems

A Transportation asset management (T.A.M.) system is a strategic resource allocation framework that allows transportation organizations to manage the condition and performance of transportation infrastructure cost-effectively. Various primers, reports, scans, and case studies have been produced in recent years discussing the role of T.A.M. systems in managing a transportation system (Federal Transit Administration, 2020). Most transportation agencies practice some degree of asset management. However, because each agency is different, there is no single asset management system or “one-size-fits-all” solution. The AASHTO's definition of T.A.M. that is used as a common point of departure is as follows;

“Transportation Asset Management is a strategic and systematic process of operating, maintaining, upgrading, and expanding physical assets effectively throughout their life cycle. It makes a speciality of enterprise and engineering practices for useful resource allocation and utilization, with the goal of higher choice making primarily based totally upon first-class facts and well-described objectives.”

FHWA’s Asset Management Primer described that the generic asset management system shown in Figure 2.1 below is used to identify the key steps in an asset management process that can include climate change considerations (Meyer, Amekudzi and O’Har, 2010). The components of this generic asset management system include goals and policies, asset inventory, condition assessment and performance monitoring, alternatives analysis and program optimization, short- and long-range plans, program implementation, and performance monitoring.

The Asset Management Handbook states that the specifics of any system must be tailored to the agency concerned and that any asset management system must be flexible enough to respond to changes in all variables (Cowe Falls *et al.*, 2001).



Source: United States, Ministry of Transport, 1999, Asset Management Handbook, FHWA.

Figure 2-1 Generic components of the asset management system

2.3.1. Goals and Policies

Goals, objectives, and enabling policies frame an asset management process within an agency. An effective asset management approach will align an agency's vision, goals, and objectives with performance measures and targets at various levels of decision making, and have enabling policies to ensure effective implementation. Most TAM programs have defined goals and objectives that guide maintenance, repair, and rehabilitation decisions. Asset management best practices include clearly defined goals and policies that can be translated into explicit performance measures and targets, and that are based on considerations of resources available to the agency (Systematics *et al.*, 2007), (Federal Transit Administration, 2020)

2.3.2. Asset Inventory

One of the critical elements of an asset management system is an up-to-date inventory of existing assets: data that identify and account for the facilities that an agency owns. An inventory typically describes the attributes of existing assets that do not change with respect to time, including their respective locations in the overall asset base. For example, roadway inventory data include information such as functional class, geometry, structure, material type, and properties. Asset inventories are developed using location referencing systems often based on a geographic information system (GIS) platform, Global Positioning Systems, and imaging and related technologies.

A good asset inventory will be updated regularly enough to provide current data on all assets (newer and older) at any time, to allow any asset to be identified as needed.

2.3.3. Condition Assessment–Performance Modeling

Condition assessment is vital to an asset management process. It is useful to transportation organizations to not only maintain data on current asset conditions but also past asset conditions. Performance modeling is a valuable tool that allows transportation officials to predict the future condition and performance of assets. Many organizations strive to maintain their assets at a minimum defined level of service (i.e., maintain at least 80% of pavements in good condition on Interstate roadways) (Report and Meyer, 2007). The level of service of infrastructure assets is often directly related to available funding. Effective asset management practices can be used to predict the future condition of assets depending on available funds. As was noted in the domestic scan, many state departments of transportation have been able to justify their funding needs to their respective state legislatures using asset management systems (Report and Meyer, 2007).

2.3.4. Alternative Analysis and Program Optimization

TAM systems typically include alternative analysis and program optimization modules or routines that help agencies specify a limited number of alternatives to meet the overall objectives of their asset management system most cost effectively. For example, an agency managing roadways may set as an objective a maximum percentage (say 10%) of the network mileage that will be allowed to fall below a certain minimum desired level of service (also specified by the agency). A set of rehabilitation and maintenance alternatives may then be developed to meet this objective, and then analyzed to determine the optimal set of alternatives to meet the specified objective at the lowest life-cycle cost (Meyer, Amekudzi and O’Har, 2010). TAM best practice will use methods and criteria that reflect stated policy objectives, performance measures, and

targets to prioritize projects. Also, projects will be evaluated in terms of realistic estimates of life-cycle costs, benefits, and performance impacts.

2.3.5. Short- and Long-Term Plans

TAM systems are a critical component of many transportation organizations' short- and long-term plans since past, present, and future infrastructure condition is an essential component of a short or long-range plan. During planning, projects are prioritized and selected. Several transportation organizations with more advanced asset management systems are able to conduct scenario analysis to determine the effect of different funding levels on asset condition as part of their alternatives analysis process.

The characteristics of an effective asset management plan include keeping it (Report and Meyer, 2007):

- Simple;
- Understandable;
- Easy to follow;
- Flexible;
- Close to the end user;
- Goal driven; and
- Reporting on progress.

2.3.6. Program Implementation

Once planning and project selection are completed, programs are implemented. These programs can relate to different types of actions (e.g., major rehabilitation or maintenance activities) as well as defining the different organizational units responsible for different actions. Program implementation often requires careful thought in terms of how an agency is going to provide the most cost-effective and strategic management of transportation system assets.

2.3.7. Performance Monitoring

To ensure that an asset management system is functioning optimally, performance monitoring needs to be done constantly to ensure that a transportation organization is meeting its goals and following its policies. Determining the performance of transportation infrastructure requires the development of effective performance measurement criteria.

2.4. Asset Management Approach

Different countries across the world use different asset management approaches. For example, as per U.S. National Cooperative Highway Research Program (NCHRP) report, State transportation

agencies like Florida, Michigan, Minnesota, Ohio, Oregon, and Utah use their approach to asset management.(Cambridge Systematics and Meyer, 2007).

The important characteristic of the asset management approach is the use of private contractors in providing many core maintenance functions called asset maintenance contracting. From states in the U.S., the Florida Department of Transportation (FDOT) was one of the first states to use such an approach significantly to satisfy its maintenance function. FDOT defines asset maintenance contracting as an “innovative, long-term, performance-based contract encompassing all (or most) maintenance functions required to serve the public and maintain the roadways within specific roadway corridors or entire geographic areas.” Typical asset maintenance contracts include (Systematics *et al.*, 2007):

- routine and non-routine maintenance activities,
- environmental regulation compliance,
- lighting and call box maintenance,
- customer service complaint resolution,
- formal inspection of bridges and appurtenances,
- motorist and service patrols,
- roadway characteristics inventory data collection, with options for a rest area,/weigh station/welcome center maintenance, and
- payment of utilities for rest areas/weigh stations/welcome centers.

Contracts can cover different geographic areas, such as corridors versus districts, focus on facility types, such as welcome centers and rest areas, or provide responsibility for a specific asset type, such as bridges.

As per U.S. National Cooperative Highway Research Program (NCHRP) report, FDOT relies on four major management systems for providing information to support investment decision-making: a pavement management system (P.M.S.), a bridge management system (B.M.S.), a maintenance management system (M.M.S.) and a maintenance rating program (M.R.P.) (Cambridge Systematics and Meyer, 2007).

Pavement Management System – An annual pavement condition survey is conducted to evaluate ride quality, crack severity, and the average depth of wheel-path ruts.

Bridge Management System –Bridge is inspected regularly or periodically to identify preventative maintenance, minor or major repair work, or replacement priorities. A bridge that meets department standards is defined as not showing evidence of structural deterioration, not being limited by weight restrictions, or not needing preventative maintenance.

Bridge needs are classified as routine maintenance, periodic maintenance and repair, and replacement. Routine maintenance needs result in the writing of a work order uploaded to the maintenance management system, which is then forwarded to a maintenance yard. Organizational performance measures have been established to monitor the effectiveness of this process. For more critical bridge needs, a deficient bridge list includes all bridges needing repair or replacement due to structural reasons. Bridges that are more economical to replace than repair will be replaced within reasonable years.

Maintenance Management System – maintenance management system (M.M.S.) is a database that includes production, personnel, equipment, and materials data. Specific maintenance activities are defined considering personnel and equipment requirements.

Maintenance Rating Program – State highway maintenance condition is based on a sampling process that rates five primary categories of the highway environment three times a year. The gadgets rated are roadway (potholes, etc.), roadside (shoulders), flowers and aesthetics (mowing, clutter removal), webweb page site visitors services (signs, lighting), and drainage (ditches). This maintenance rating program (M.R.P.) " provides information to schedule and prioritize routine maintenance activities and to provide uniform maintenance conditions that meet established departmental objectives.

The characteristics of each M.R.P. element include:

- ❖ Roadway Characteristics: Flexible pavement pothole, Flexible pavement edge raveling, Flexible pavement shoving, Flexible pavement depression/bump, Flexible pavement paved shoulder/turnout, Rigid pavement pothole, Rigid pavement depression/bump, Rigid pavement cracking; and Rigid pavement paved shoulder/turnout.
- ❖ Roadside Characteristics: Unpaved shoulder, Front slope, Slope pavement, Sidewalk; and Fence.
- ❖ Traffic Services Characteristics: Raised pavement markers, Striping, Pavement symbols, Guardrail, Attenuators, Signs less than 30 square feet, Signs greater than 30 square feet, Object markers; and Highway lighting.
- ❖ Drainage Characteristics: Side and cross drains, Roadside and median ditches, Outfall ditches, Inlets, Miscellaneous drainage structures; and Roadway sweeping.
- ❖ Vegetation Aesthetics Characteristics: Roadside mowing, Slope moving, Landscaping, Tree trimming, Curb and sidewalk edging, Litter removal; and Turf condition.

All characteristics are evaluated against established standards, and an overall maintenance condition is calculated.

2.5. Road Asset Management Challenges

Road asset infrastructures are the public organization's largest, most valuable, and most visible assets. Asset management covers the whole life cycle of the physical assets, including construction, maintenance, and disposal (Denton, P. and McIlroy, 2018). However, most countries develop asset management capability within their technical ranks, usually within Engineering Services. This isolates asset management as a technical function rather than a broader concept that embraces the development of relationships between those who deliver services, those who maintain and develop infrastructure to support the delivery of those services, and those who plan for future service provision (Godau, 2008).

As the Research done in the area of road asset management shows, there are different challenges that road asset management faces across different continents and countries, and the challenges and prospects of implementing the asset management principles are different from country to country and organization to organization in any country. Some of those identified challenges are (Denton, P. and McIlroy, 2018);

- Organizational culture and a decision-making process that requires top-level commitment;
- Organizational attention and the ability how to manipulate asset data at an area network level, which supports the change in behavior and outcomes;
- Inaccurate and conflicting data collection;
- Asset management awareness
- Asset management knowledge

Besides those challenges stated above, financial challenges, overall asset management system, political awareness, and professional competency are other major problems identified in road asset management (Semunigus, 2020).

2.6. Technological use in Road Asset Management Practice

Digitizing the road information can enhance an improved standard of the working environment of people by enabling a flexible and easy database for users. For example, inventory management of road maintenance with a digitized system supports the easy update of information and reduces the time spent extracting required data (Beto, 2021).

The commonly identified Technological application in Road asset management by different researchers are the following.

1. Robotic and autonomous systems (R.A.S.) for road asset management

The development of Robotics and autonomous is to use it in detecting road defects and cracks and repairing them, including a developed 3D printer for sealing cracks. The ambition is to change radically the way that asphalt pavements are repaired by developing an automated system for locating defects (cracks and potholes) in the road surface while they are still relatively small and deploying an autonomous robot to repair them before they become defects requiring street work intervention. This can revolutionize how roads are maintained while reducing road closures, risks to operators, and indirect costs incurred by road users due to street works (Infrastructure, 2020).

As per researchers' investigation, R.A.S.s are used on automated condition assessment and repair that informed the development of the automation aspect of road inspection and repair. In addition, a researcher stated that R.A.S.s had been utilized in the construction industry with various applications, including tying steel reinforcements, bricklaying, welding and installation of steel frames, earthwork, and excavation (K. N. NARASIMHA and VINAY, 2019). R.A.S.s have also been utilized to tackle the challenge of working in harsh conditions and environments (Li and Leung, 2017). For instance, robots have been used for working at heights to install window glass and steel modules.

2. Automatic Road Survey by Using Vehicle Mounted Laser for Road Asset Management

The Automatic Road Survey by Using Vehicle Mounted Laser for Road Asset Management is a rapid and inexpensive measurement of a major mode of local road deterioration, namely fretting. A researcher described that a point laser system fitted to a moving vehicle captures road surface information in the Automatic Road survey method. Next, the collected raw data is analyzed to identify road surface fretting. The technique consists of pre-processing to put off sign noise comprising an adaptive thresholding approach for sensor noise elimination and a baseline correction to account for automobile dynamic motion. Afterward, a global-local histogram analysis technique is used to estimate two features from road surface fretting. Although the proposed system focuses on network-level road condition assessment, it is verified using visual inspection data collected from several road surface types (Li, Burrow and Metje, 2020).

In addition to Automatic Road Survey by Using Vehicle Mounted Laser for Road Asset Management, several automated systems for capturing road surface information that is available include systems such as;

- using video (Zhang *et al.*, 2016)

- smartphones (Kumar, Mukherjee and Singh, 2017)
- Ground Penetrating Radar (GPR) (L. Krysiński and J. Sudyka, 2013)
- laser technologies for road information inventory (H. Guan, J. Li, S. Cao, and Y. Yu., 2016) and
- road marking recognition (M. Cheng, H. Zhang, C. Wang, and J. Li, 2017)

2.7. Ethiopian Roads Administration, Road Asset Management Practices

Ethiopian Roads Administration (ERA) plays a crucial role in managing the country's road network through structured Road Asset Management (RAM) practices. This part presents document reviewed to assess ERA's Road Asset management practice and its challenges. The primary focus areas for investigation encompassed the methods employed in road asset management by ERA, such as road maintenance by both own forces and private contractors, axle load control, road traffic surveys, asset inventory and data management systems, and road policy and strategies.

2.7.1. Road Maintenance Contractor (Own Force)

In pursuing a thoroughly integrated strategy to enhance the road asset management system aimed at improving accessibility and addressing the poor state of roads, Ethiopia ranks among the leading countries in enhancing its road connectivity and access framework (Ethiopian Roads Administration, 2022). The road sector has undergone significant reform, and the government has continued to invest in road development to achieve the goal of enhancing accessibility and connectivity, thereby transforming socio-spatial landscapes and promoting economic growth. However, the absence of a comprehensive road asset management approach in Ethiopia has resulted in a significant backlog of road maintenance tasks. Subsequently, the Road Maintenance Initiative (RMI) program was launched, which established the Road Fund that is now managed by the Road Fund Directorate under the Ethiopian Roads Administration. The RMI framework has been applied to the road sector programs, providing foundational elements for management, ownership, financing, and accountability in sustainable management practices. This has led to the establishment of Road asset management and financing initiatives (Ethiopian Roads Administration, 2022).

The road asset management system encompasses primary pavement structures, roadside amenities and facilities, bridges and culverts, earthworks, drainage systems, safety barriers, lighting, signage, trees, and vegetation. Roads are valuable public infrastructure assets for a country, necessitating regular monitoring and evaluation to ensure financial efficiency. Effective

road asset management is crucial for ensuring proper utilization and governance. A robust asset management system enables informed decision-making across all levels, particularly for those involved in road management. To this end, the Ethiopian Roads Administration has integrated the Ethiopian Construction Works Corporation (Road Maintenance District) within its organizational structure, and is currently managing road asset management (road maintenance) internally. This in-house road maintenance contractor is actively engaged in various aspects of Road Asset management including routine, periodic, heavy maintenance (asphalt concrete overlay), and other urgent maintenance tasks. According to the Road Sector Development Program (RSDP) covering a 24-year period, Ethiopia boasts a total classified road network of approximately 28,000 km, with a road density of roughly 4.2 km per 10,000 individuals, and 23 km per 1,000 square kilometers of the overall land area. The report indicates that 597 km of heavy maintenance (overlay) and 18,997 km of periodic maintenance have been executed under this program. ERA has been maintaining road projects through its Road Maintenance Contractor (own force) also, which would be prohibitively costly if outsourced to private contractors, due to challenges such as difficult terrain, remote locations, and the urgent nature of the work.

2.7.2. Private Contractors

Private Contractors often play a significant role in the construction, maintenance, and rehabilitation of roads, contributing to the overall management of road assets.

Here are some key roles and contributions of private contractors in road asset management:

1. **Construction and Expansion:** Private contractors are often engaged by ERA to undertake road construction and expansion projects. They bring expertise, specialized equipment, and resources necessary for the efficient and timely completion of road infrastructure projects (Hanisch, 2020).
2. **Routine and Periodic Maintenance:** Private contractors are often hired by ERA to carry out routine maintenance activities on road assets. This includes activities such as pothole repairs, surface resealing, vegetation control, and cleaning of drainage systems. Private contractors play a crucial role in ensuring that the roads are maintained in good condition, enhancing the longevity and performance of the road assets. Private contractors are also engaged in periodic maintenance activities, which involve more substantial interventions such as resurfacing, rehabilitation, and reconstruction of roads. These activities help restore the structural integrity of the roads and extend their lifespan (World Bank, 2018).

3. **Emergency Repairs:** During emergencies such as natural disasters or unforeseen events, private contractors can be engaged to carry out urgent repairs and restore road functionality. Their expertise and resources are crucial in quickly addressing damages and minimizing disruptions to the road network (Ethiopian Roads Administration, 2022), (Federal Highway Administration, 2007)
4. **Technology and Innovation:** Private contractors often bring innovation and advanced technologies to road asset management practices. They may introduce new construction techniques, materials, and equipment that can improve the quality and efficiency of road infrastructure projects. These technological advancements can contribute to better asset management practices and overall road network performance (Zhang *et al.*, 2016).
5. **Performance-based Road Maintenance Contracts:** Performance-based road maintenance contracts (PBCs) have been shown to enhance road asset management by holding contractors accountable for meeting specific performance targets. Research by the World Bank (2021) highlights that performance-based contracts can lead to better budget forecasting, consistent outcomes, faster emergency repairs, risk transfer to the private sector, reduced long-term procurement costs, and simplified contract administration. By utilizing performance-based road maintenance contracts, ERA can ensure that private contractors are accountable for delivering high-quality road asset management services while also encouraging innovation and efficiency in maintenance operations (World Bank, 2021). Additionally, research from the Mineta Transportation Institute (Zhao *et al.*, 2020) indicates that PBCs offer flexibility in adopting new materials, designs, and technologies to achieve predetermined performance targets. This adaptability encourages innovation among contractors, leading to improved maintenance quality and timely project completion. By utilizing performance-based road maintenance contracts, ERA can ensure that private contractors are accountable for delivering high-quality road asset management services while also fostering efficiency and sustainability in road maintenance and rehabilitation of road assets management practices.

2.7.3. Axle Load Control System

Special attention has been given to the enforcement of axle load limits by the ERA as part of efforts to protect the nation's road assets from premature deterioration. To ensure effective enforcement, the operation of the weighbridge stations is placed under the direct supervision of ERA. Fourteen stationary weighbridges are strategically located along the country's major routes and operate continuously 24 hours a day, 7 days a week to provide wide coverage over the main transportation corridors. Enforcement is further strengthened by deploying mobile weighbridges

for random axle load control activities. Three mobile teams operate in different regions to cover routes that may not be directly served by the stationary stations, thereby reducing the chances of overloaded vehicles evading checks.

At each station, data on individual axles of every heavy vehicle is recorded, and summary reports are submitted to ERA headquarters on a monthly basis. These data are then collated and analyzed to generate an annual axle load report, which forms an integral part of the overall road condition report. Since March 2004, an off-loading policy has been implemented at all weighbridge stations overloaded vehicles are required to offload their excess cargo on site, and operators are subject to penalties in nearby courts. This systematic approach has led to significant improvements in enforcement and, ultimately, in the preservation of road infrastructure. (Japan International Cooperation Agency. (n.d.). The Project for Improvement of Axle Load Control on Trunk Roads).



Source: ERA, Road Asset Management

Figure 2-2 Axle Load Control

However, the level of penalty is so small that it does not have a serious effect on persistent offenders. Maintenance of weighbridges, renovation of stations to improve the working conditions at the stations, regular monitoring and intensive use of the mobile weigh scales are some of the activities that has been being undertaken by ERA. With the exception of 2006/07 and 2015/16 fiscal year, the number of checked front and rear axles had increased from year to year. Because of conflict and closure of weighbridge stations; the number checked front and rear axles had declined in 2017/18. The number of illegal axles has decreased from 38% (in 2003/04)

to 6% (in 2015/16). Starting from 2016/17 - 2017/18, the portion of illegal axle load has increased which could be due to the lower level of total axles checked compared to the previous year, i.e., 2015/16. The monitoring system has been more strengthened than before both by increasing number modernization of the weighbridge stations.

ERA has conducted the “Project for Improvement of Axle Load Control on Trunk Roads” in collaboration with JICA from 2015 to 2018, on all its 14 stations with the objective of modernizing the system by changing the single-axle manual weighbridge system to multiple-axle automated weighbridge control system and ultimately to improve the efficiency and transparency of axle load control. The trend in the Illegal Axle Load data from the 2002/03 to 2020/2021 is presented in Table 2.2 and Figure 2.3 below.

Table 2-2 Total checked front and rear Axles (2002/03 – 2020/21)

Year	Axles				
	Total Checked			Illegal	Illegal %
	Front	Rear	Total		
2002/2003	86,122	216,279	302,401	113,708	38
2003/2004	88,427	228,528	316,955	109,987	35
2004/2005	105,476	309,422	414,898	149,145	36
2005/2006	113,876	320,997	434,873	157,688	36
2006/2007	99,477	317,303	416,780	136,944	33
2007/2008	115,565	378,107	493,672	159,598	32
2008/2009	141,359	459,950	601,309	179,181	30
2009/2010	148,046	485,947	633,993	89,940	14
2010/2011	142,253	473,406	615,659	76,013	12
2011/2012	132,344	493,160	625,504	36,897	6
2012/2013	173,024	556,258	800,504	71,222	9
2013/2014	180,384	619,871	851,249	50,994	6
2014/2015	196,719	642,626	909,700	70,355	8
2015/2016	81,014	256,497	337,511	20,537	6
2016/2017	189,879	641,196	831,075	114,021	14

2017/2018	142,253	473,406	615,659	76,013	12
2018/2019	78,194	288,279	366,473	81,044	22
2019/2020	149,562	538,731	688,293	158,752	23
2020/2021	145,565	551,866	697,431	233,080	33

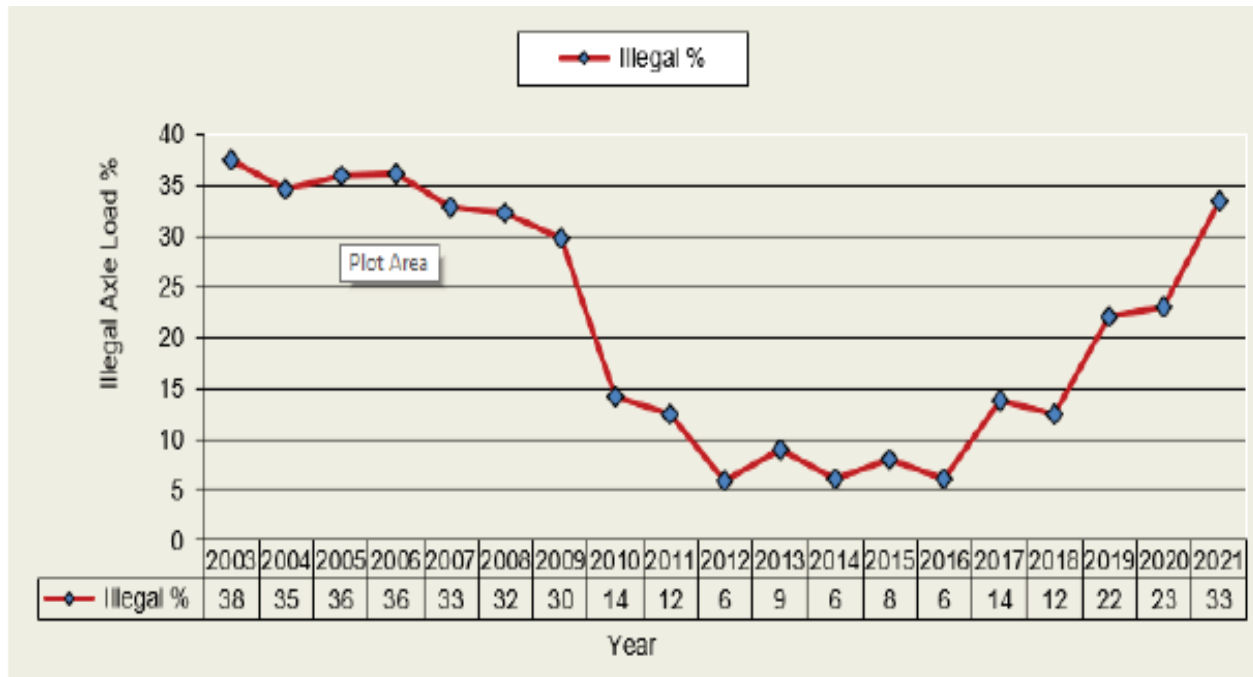


Figure 2-3 Percentage of Illegal Axle Load

2.7.3.1. Comparison of Ethiopian Roads Administration Axle load control system practice effectiveness to other African Countries' practice

Ethiopia's axle load control system has undergone significant improvements over the years, notably through the collaboration with the Japan International Cooperation Agency (JICA) from 2015 to 2018. This partnership aimed to modernize weighbridge stations by transitioning from single-axle manual systems to multiple-axle automated systems, enhancing both efficiency and transparency in axle load control. These efforts contributed to a reduction in illegal axle loads from 38% in 2003/04 to 6% in 2015/16.

However, challenges persist. The penalties for overloading in Ethiopia have been considered insufficient to deter repeat offenders effectively. For instance, a study focusing on the Holeta and Modjo weighbridge stations revealed that in one week of June 2013, 66% of vehicles at Holeta and 45.3% at Modjo were found to be overloaded. The study highlighted the need for standardized procedures and more stringent penalties to enhance compliance (Biniyam, 2015).

In comparison, **Kenya** has made notable strides in axle load control. The Kenya National Highways Authority (KeNHA) has implemented high-speed weigh-in-motion technology, allowing vehicles to be weighed without stopping, thus improving efficiency and reducing congestion at weighbridges. This technology has contributed to a compliance rate of 97% with axle load limits on Kenyan highways (Kenya National Highways Authority, 2022). Additionally, Kenya has constructed over 11 static weighbridges and 23 virtual weighbridges, complemented by 23 mobile weighbridge units, to monitor different road networks effectively (Kenya National Highways Authority, 2022).

Uganda, on the other hand, has faced challenges with weighbridge operations, which have been identified as hindrances to the free movement of imports and exports. The country has implemented weigh-in-motion technology to address these issues, aiming to measure vehicle weights at normal speeds and reduce delays (Infrastructure.go.ug, 2022).

In **Botswana**, axle load control is conducted at various weighbridge locations, operating between 06:00 hrs and 22:00 hrs, with some stations operating 24 hours. The process involves weighing vehicles above 3,500 kg and issuing certificates upon weighing. Notably, there is no cost associated with this service (Government of Botswana, 2022).

Overall, while Ethiopia has made commendable progress in axle load control, particularly through modernization initiatives, there remains room for improvement, especially in enforcing deterrent penalties and standardizing procedures. Learning from Kenya's implementation of advanced technologies and comprehensive monitoring systems could further enhance Ethiopia's axle load control effectiveness.

2.7.4. Road Traffic survey

The deterioration of paved roads caused by traffic results from both the magnitude of the individual wheel loads and the number of times these loads are applied. It is necessary to consider not only the total number of vehicles that will use the road but also the wheel loads (or, for convenience, the axle loads) of these vehicles. Equivalency factors are used to convert traffic volumes into cumulative standard axle loads and this is discussed in this section. For paved roads, traffic classes are defined by ranges of cumulative number of equivalent standard axles (ESAs) (ERA, 2011).

For the effective planning of new road constructions and road improvements, past, present and reliable forecasts for future of travel movements are essential. The past traffic, estimated current

and forecasted traffic volumes on any proposed road project constitutes the most important factor for determining design standards, construction and maintenance costs of the road.

The Road Project diversifies the transport pattern, with the view that road transport is the backbone of modern transport system in the area. In other word, direct impact of the road projects on transport development includes traffic flows (normal, diverted and generated traffic) with respect to the existing pattern of transport services and transport costs. The conducted and estimated here is the volume of traffic that would obtain without the project, pre-road construction and upgrading existing is normal traffic.

Normal traffic that is currently travelling between the terminal of the roads and that can be reasonably expected to continue to use the same road regardless of the intervention envisaged. This component of the traffic stream is the same as the volume of traffic noted during the traffic count.

Once the project road is realized, it is assumed that the level of traffic to be generated is triggered by decrease in transport cost subsequent to the improvement scheme. The improvement effects, involving changes in geometric and pavement feature of road, are thus expected to result in increased demand for travel, on ground that operators tend to cut fares given the incentive provided by the intervention and the expected knock-on effects (the creation of competitive business environment).

Currently ERA is carrying out traffic count traffic count three cycle a year for seven days for each cycle. This traffic counts conducted for 12hr for five days and 24hr for two days for the determination Night factor to convert the manual count 12-hour totals into flow figures that conducted one on the weekdays and the other on the weekend to incorporate the difference in the traffic flow (ERA, 2011).

Using these data ERA produces three reports of average daily traffic (ADT) for each segment for the three cycles. More over ERA produce annual average daily traffic (AADT) during the third cycle by incorporating the seasonal factor.

A typical year was divided into three four-month time periods based on the climate, traffic and pedestrian flows (ERA, 2011). The four-month intervals were June-September, October-January and February-May.

The annual traffic counts carry out on the following periods:

1. First cycle from February 1 to 7

2. Second cycle from July 1 to 7
3. Third Cycle from November 1 to 7

The Ethiopian Roads Administration seeks to improve the management and maintenance of the federal road network by recognizing that the road network is the country's major asset and not having optimal system for management and maintenance for assets generally will be a burden on the country's national economy. Lack of appropriate asset management tools will result in deterioration and as a consequences in massive reduction of road asset value, increase vehicle operating cost (VOC) and reduce driving quality as well as have negative impact to national economic development.

Currently ERA is implementing different maintenance approaches to preserve the road network such as preventive maintenance, periodic maintenance and output and performance-based maintenance. The implementation of these approaches was hindered largely due to shortage of available budget and qualified staff. And these were the setbacks for ERA to manage its road networks more effectively. Traffic counts carried out over a short period as a basis for estimating the AADT can produce estimates which are subject to large errors because traffic volumes can have large daily, weekly, monthly and seasonal variations. The daily variability in traffic volume depends on the volume of traffic, with particularly high variability on roads carrying less than 1000 vehicles per day. Traffic volumes vary more from day-to-day than from week to-week over the year. Thus there are large errors associated with estimating annual AADTs from traffic counts of only a few days duration, or excluding the weekend. For the same reason there is a rapid decrease in the likely error as the duration of the counting period increases up to one week. For counts of longer duration, improvements in accuracy are less pronounced. Traffic volumes also vary from month-to-month (seasonal variation), so that a weekly traffic count repeated at intervals during the year provides a better base for estimating the annual volume of traffic than a continuous traffic count of the same total duration. Traffic also varies considerably through a 24-hour period and this needs to be taken into account explicitly as outlined below.

Based on the above, and in order to reduce error, it is recommended that traffic counts to establish AADT at a specific site conform to the following practice:

The counts are for seven consecutive days.

- I. The counts on some of the days are for a full 24 hours with, preferably, at least one 24-hour count on a weekday and one during a weekend. On the other days 16-hour counts should be

- sufficient. These should be extrapolated to 24-hour values in the same proportion as the 16-hour/24-hour split on those days when full 24-hour counts have been undertaken.
- II. Counts are avoided at times when travel activity is abnormal for short periods due to the payment of wages and salaries, public holidays, etc. If abnormal traffic flows persist for extended periods, for example during harvest times, additional counts need to be made to ensure this traffic is properly included.
 - III. If possible, the 7-day counts should be repeated several times throughout the year. Countrywide traffic data should, preferably, be collected on a systematic basis to enable seasonal trends in traffic volumes to be quantified.

2.7.5. Road Sector Policy of ERA

Road transport is the most dominant mode of transport in Ethiopia, accounting for more than 92 - 93 percent of passenger and freight movements, which has a crucial impact on sustainable development ('The Federal Democratic Republic Of Ethiopia, Ministry of Urban and Infrastructure, Ethiopian Roads Administration', 2024). Despite the progress made in the development of the road network over a period of more than two decades, the efficiency, effectiveness and sustainability of the sector are still not very good standards in terms of functional standards and performance, partly due to the lack of a road sector policy that should guide the formulation of medium and long-term strategies and plans, to improve access and mobility in an optimal integrated manner and to preserve the road heritage, to contribute to solving the problem of road safety, environmental impacts and negative social problems, as well as to respond to climate change through mitigation and adaptation. The lack of a road sector policy has limited the scope of redefining the functions and responsibilities of road sector agencies in relation to the role of relevant ministries and regulatory bodies (mainly the separation of policy, law, regulation, planning, management and operation) and modernizing the governance structure and institutional framework to respond to customer-focused and efficiency-based management, with sufficient autonomy and an appropriate accountability mechanism that ensures the provision of commercial-type services, guaranteeing a sustainable financing mechanism. Draft Road Sector Policy has been developed to guide the sustainable development of roads, creating an accountable governance structure and institutional framework, financing arrangements, comprehensive asset management and coherent and integrated planning. It is fundamentally based on the GoE's development agenda and the objectives of sector modernization and institutional transformation.

A. Objectives of the road sector policy

According to the Road Sector Development program 24 Years Assessment Report (Ethiopian Roads Administration, 2022) the main objectives of the road sector policy are defined to help;

- Facilitate the efficiency of road transport;
- Improve the government structure and the institutional environment, to achieve progress in terms of efficiency (business type management);
- Clarification of the roles of sectoral agencies, relevant regulatory authorities and ministries;
- The promotion of transparency, responsibility and participation of interested parties;
- Write a adequate road network planning system and design procedures to optimize resources and investments, with a strategic focus towards general management and preservation of assets;
- Rationalization of the mitigation of negative environmental and social impacts;
- Strengthen climate change adaptation and mitigation;
- Improve the provision of regular and adequate maintenance of the road network to achieve progress in terms of efficiency, reliability and sustainability;
- Enter a mechanism to enhance sustainable financing, through the principle of the user pays (covering the cost of maintaining the asset), and a greater participation of the private sector (PSP) and public-private partnership (PPP) to reduce the size of public sector budget allocations. and external loans;
- Improve the strategic direction of road and transport research; and
- Strengthening the capacities of the agencies of the road sector, with an emphasis on meeting the future needs of qualified, professional and managerial manpower, and on the use of integrated information management systems, ICT and IST, and be focused on the preparation of new projects, purchase, contract. preparation, contract, negotiation, business management, finance and administration of contracts related to contracts and performance of results, and PPP as a source of financing and provision of infrastructure.

B. Strategic Issues - in brief

According to the Road Sector Development program 24 Years Assessment Report (Ethiopian Roads Administration, 2022), the strategic issues to be addressed in the road sector policy are:

- General failure to create a responsible sectoral governance structure, institutional arrangements and efficiency, which hinder progress towards results-oriented and user-oriented management; as a key factor of sustainability;
- Gaps in economic and financial sustainability, particularly in relation to project planning and development, road safety, asset management and asset preservation, financing

mechanisms, limit progress towards desired results, as well as inadequate interaction between project planning and design and constraints. in design preparation contribute to time and cost;

- Insufficient attention to the integration of measures to mitigate environmental and social impacts, as well as climate change mitigation and adaptation, from the initial stages of project identification, selection, pre-feasibility and feasibility studies to the design and preparation of contract documents and ensuring compliance with environmental clauses in work contracts;
- Lack of a strategic approach to guide road and transport research, and of standardized procedures for selection and prioritization, as well as for the systematic evaluation of results and their dissemination; and
- Limited responsibility for building capacity holistically, to meet current and future needs for modernization and institutional transformation.

2.7.6. Methods of Data Collection Adopted in ERA

2.7.6.1. Road Asset Inventory Data Collection

The Ethiopian Roads Administration (ERA) employs a variety of data collection methods to gather comprehensive information about road assets (Semunigus, 2020). These methods are designed to ensure the effective management, maintenance, and planning of the nation's road infrastructure. This data collection process is not just about addressing immediate needs but also plays a crucial role in long-term planning for future road development projects.

A. Manual Road Asset Data collection

Field Surveys (Visual Inspection): Field surveys are one of the most traditional and foundational methods used by ERA for data collection manually. Trained personnel visit road sites visually to conduct on-site evaluations or road condition rating. This method provides a direct, hands-on assessment of the road assets. During these inspections, trained personnel visit the road sites to examine key infrastructure components, such as:

- **Road Surfaces:** Checking for cracks, potholes, and overall wear and tear.
- **Bridges:** Assessing structural integrity, signs of corrosion, and load-bearing capacity.
- **Drainage Systems:** Evaluating the efficiency of water drainage to prevent flooding or erosion.
- **Other Infrastructure:** Reviewing elements like guardrails, signage, and lighting for functionality and safety.

After these visual inspections, each road asset is assigned a condition rating based on predefined, standardized criteria. This rating system ensures consistency and objectivity in the assessments, helping to prioritize maintenance tasks by identifying which assets require urgent attention and which can be addressed later (World Bank, 2018), (Semunigus, 2020).

Besides to data collection for Road inventory data ERA collects Road Traffic data manually which is one of the foundational methods for collecting traffic data. This involves such as On-Site Observations: Trained personnel conduct manual counts of vehicles at selected locations over specified periods. Starting from February 2021 after the White Knight Construction Management Consultants Plc. Developed GIS provided database, ERA is currently undertake Road Traffic survey data collection by smart phone (GIS provided Mobile) and analysis done by desktop database developed by the consultant.

B. Automated Data Collection (Technological Tools and Equipment)

Automated systems use sensors and imaging technology to collect detailed data on road and roadway conditions. The automated equipment currently used by ERA includes the Hawkeye 1000 and the Falling Weight Deflectometer (FWD); the Hawkeye 2000 is not yet fully functional. In addition, advanced devices such as the Automated Road Analysis (ARAN), Heavy Duty Deflectometer (HWD), and Moving Weight devices are employed to assess both the structural and functional conditions of the pavement. From ARAN tests, parameters including roughness (roll), rut depth, surface macro-texture, and surface deterioration are collected. The HWD test calculates the layer modulus and the remaining structural life of the pavement. In the moving weighing study, the current axle load is determined, which is then used to estimate the remaining service life of the road. These automated approaches enable rapid, non-destructive, and highly accurate evaluations that are essential for modern pavement management and asset preservation strategies (Al-Kathairi, 2014), (Ahmed, 2024).

C. Other Data Collection Methods adopted by ERA

- a) **Project History Data Review** – A comprehensive review of project history data is a critical step in assessing the performance and condition of road infrastructure. This process involves analyzing a wide range of documents and records from past projects, including:
- **Contract Documents reviews:** These provide detailed information about the scope, specifications, and terms of previous projects, offering insights into design expectations and contractor obligations.
 - **Progress and Completion Reports reviews:** These reports document the execution of the project, highlighting key milestones, challenges encountered, and the quality of work

delivered. They also provide a record of deviations from the original plan, if any, and the corrective actions taken.

- **Working Drawings reviews:** These detailed technical drawings illustrate the as-built condition of the infrastructure, including modifications made during construction. They serve as a baseline for understanding the structural and functional aspects of the road assets.
- **Other Project-Related Data reviews:** Additional data, such as geotechnical reports, traffic studies, and environmental assessments, resettlement and Right of way compensations related data are also reviewed to gain a holistic understanding of the project context.

b) **Data collection from Axle Load control** - Ethiopian Roads Administration (ERA) has established Axle Load Control Stations strategically positioned along various locations on the trunk road network. These stations are equipped with semi/ advanced weighing systems to monitor and regulate the axle loads of vehicles traversing the roads. The primary objective of these stations is to ensure compliance with load limits, which helps in minimizing the adverse effects of overloading on road infrastructure. Through these stations, ERA collects extensive data on vehicle weights, traffic volumes, and the frequency of overload occurrences. This data is crucial for understanding traffic patterns, road usage, and the stresses imposed on road assets. By analyzing this information, ERA assess long-term demands placed on the road network and develop strategies to enhance its durability and efficiency (Rehabilitation and Design, 2013). Moreover, the axle load control data supports planning and decision-making processes, such as:

- Prioritizing maintenance and rehabilitation projects for road segments prone to damage from overloading.
- Designing roads with appropriate structural capacities to accommodate expected traffic loads.
- Enforcing regulations to reduce overloading and extend the service life of roads. In addition to its technical benefits, the axle load control system contributes to improving road safety by mitigating risks associated with overloaded vehicles, such as accidents and structural failures.

c) **Data from Stakeholder and Community in the project area-** ERA recognizes the critical role of engaging local communities and stakeholders in the effective planning, maintenance, and management of road infrastructure. Stakeholders, including residents, businesses, local government representatives, and transport operators, provide valuable qualitative insights

that complement technical assessments. Stakeholders and community members often highlight localized problems, such as drainage issues, potholes, or safety hazards, that might not be evident through routine technical inspections (Associates, Engineers and Pvt, no date). But it's noted that, the records from stake holders and community in the project area are not evident.

2.7.6.2. Road Asset Data Management Systems in ERA

ERA employs different Road Asset Data Management Systems to oversee and maintain its vast network of road infrastructure which serve as a backbone for effective asset monitoring, data integration, and informed decision-making. The road asset data management system experienced by ERA are Centralized Data data management such as Bridge and Culvert Management System (BMS) to manage specific infrastructure components like bridges and culverts, Ethiopian Roads Asset Management System (ERAMS) that used for Project Data Management such as timelines, budgets, contractors, and progress updates and to evaluate project outcomes, adherence to schedules, and resource utilization, Road Traffic Survey data, Besides to BMS and ERAMS most of road asset data in ERA are collected manually and simply stored in personal computer and not well managed specially Road Condition data, Project RoW compensation history, are not centrally managed (Semunigus, 2020). Hence, to overcome such short comings ERA shall have centralized system for all Road Asset compenents in its management that allows easy access to authorized personnel, enabling efficient data retrieval for analysis, reporting, and planning purposes. In addation ERA shall have to establish methods for regularly reviewing its data management systems to incorporate new technologies and methodologies such data Automation center, real-time data integration, and GIS mapping capabilities for the advancements to improve system efficiency and usability.

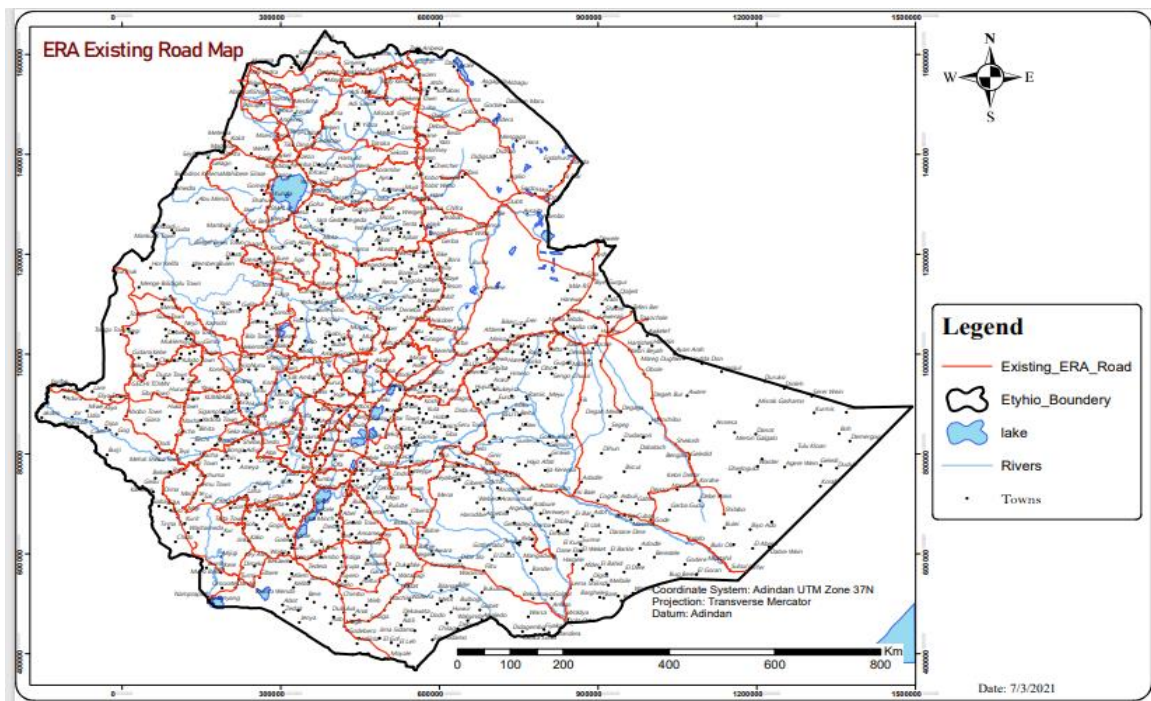
CHAPTER 3

3. RESEARCH METHODOLOGY

The research methodology generally depends on qualitative and quantitative research approaches based on intensive data collection through different techniques, namely, desk study, questionnaires and Interviews.

3.1. Research Area

The study was undertaken on Road assets Management unit of the Ethiopian Roads Administration that administers Road asset under ten (10) road networks and maintenance districts.



Source: E.R.A. Road Asset Management

Figure 3-1: Study area map

3.2. Research Design

The study specifically adopted a descriptive research design. It is considered a suitable and available research design to describe Road asset management practice and its challenges in the Ethiopian Roads Administration. The Research addressed through survey design methods: questionnaires and interviews. Also, archival data obtained from literature and desk studies aided the design of the procedural framework of the Research.

3.3. Study Variables

The dependent and independent study variables considered to assess Road asset management practice and its challenges in the Ethiopian Roads Administration. The independent variable is more related to specific objectives, and the dependent variable is more related to general objectives.

- ❖ Independent variables: -
 - Road asset management methods
 - Technological availability and usage
 - Data management and inventory,
 - Decision-Making Process (Level),
 - Organizational culture
 - Goals strategies and Policies,
 - System planning and programming
 - Financial Resources
- ❖ Dependent Variable: Effectiveness of Road Asset Management practice and/or performance.

3.4. Population and Sampling Method

The population of this research is an employees (Professional Staff (Engineers)) of the Ethiopian Roads Administration who directly or indirectly involved/ participated in the Road Asset Management process. The method that adopted to select the study area and research participants was purposive sampling techniques.

The sample size of the population was determined using the following formula, Yemane (1967).

$$n = \frac{N}{1+N*e^2} = \frac{135}{1+135*0.05^2} = 101 \text{-----} [\text{Eq. 3.1}]$$

Where: n= Sample size

N= Total population (Only Professional Staff (Engineers) in Road Asset Management)

e= Occurrence of error, e=100%-95%=5% (assuming the confidence interval is 95%).

3.5. Sources of Data and Data Quality

In order to achieve the stated objectives, primary and secondary data were utilized in the study; the primary data were generated by using tools such as questionnaires and interviews. The secondary data were collected from different materials such as books, journals, magazines, published and unpublished materials, and online sources.

To assure the quality of the data and its fitness some tasks were done, like group discussions were prepared in order to avoid errors in data, which consider the willingness of the respondents to collaborate, the questionnaire were simple and clear for the increasing willingness of respondents, close supervision and cross-checking of responses obtained was done.

3.6. Data Collection Procedure

Desk study, interview and questionnaire are the method adopted in the collection data for this research.

3.6.1. Desk study

In addition to data collection methods involving interviews, and quantitative data sources, conducting a desk study is an important component of research on the assessment of road asset management practices and challenges within the Ethiopian Roads Administration (ERA). A desk study involves reviewing and analyzing existing literature, reports, policies, and relevant documents related to the research topic.

3.6.2. Questionnaire

After conducting desk study a questionnaire intended to answer a research question were developed and distributed to a purposively selected respondents. The developed questionnaire are specifically related to specific objective of the study. The data collection process of the questionnaire were administered by close follow-up and necessary clarification for respondents while filling out a questionnaire was given to minimize data collection time and avoid confusion. The questionnaire survey contains some close-ended questions and rating scale questions. The close ended questions are often easier and quicker for to record and code the responses obtained from the respondents, and also easier and quicker for the respondents to fill (circle) the responses. The questionnaire categorized in to parts. The first part is about Personal Information of the respondent, the second part is about questionnaire related to methods of road asset management practices, the third part is about questionnaire related to Technological Advancement in Road Asset Management practice and the last part of the questionnaire focused on questionnaire related to current challenges in Road asset management practice of ERA. The whole section of the questionnaire is presented on Appendix part of the research for further reference.

3.6.3. Interviews

Interviews allow for in-depth exploration of the perspectives, experiences, and insights of key stakeholders involved in road asset management. An interview was conducted with the selected two Directors and three Team leaders in Road Asset Management to collect data based on semi-

structured questions prepared. The interview question are attached on the appendix part of the research.

3.7. Data Presentation and Analysis

The data collected in the desk study were analyzed in relation to the theoretical statements and the method used to analyze the data from the interviews and questionnaires was the descriptive statistics method. This method of analysis allows the analysis of the responses in real numbers. A rating scale is one of the most common formats for asking respondents about their opinions or views on an event or attribute. In this regard, participants were asked to indicate the level of implementation of asset management components and the causes of road asset management implementation problems, rating them on a five-point scale (1 = very low, 2 = low and 3 = medium, 4 = high and 5 = very high). All data that were collected and analyzed, as well as the results generated, were organized and summarized to reach meaningful conclusions and convey the required recommendations. Secondary data were used as an additional source of information. The Statistic Package for Social Science (SPSS), which was used to enter the respondents' scores for each factor, helped with the analysis. As a result, the questionnaire responses were statistically analyzed to gain additional understanding. Each factor's contribution to overall performance was looked at, and the attributes were ranked according to respondents' perceptions of their criticality using the Relative Importance Index (RII), which was calculated using equation [3.2].

$$RII = \frac{\sum W}{A \times N}, (0 \leq RII \leq 1) \text{ ----- [Eq. 3.2]}$$

where W, which goes from 1 to 5, represents the weight that the respondents assigned to each factor; "5" stands for "Very high," and "1" for "very low."

N is the total number of responders, and A is the highest weight, or 5 in this instance.

3.8. Checking Reliability and Validity of Collected Data

The reliability and validity of collected data checked through Cronbach's alpha coefficients. Accordingly, from the collected data via questionnaire and analysis done with SSPS the Cronbach's alpha coefficients of the data was found 0.851. This high values of Cronbach's alpha coefficient ($\alpha = 0.851$) indicates strong internal consistency and reliability of the data collection tool. According to George and Mallery (2003),(Allevato, 2019) a Cronbach's alpha value above 0.80 is considered good, ensuring that the questionnaire items measure the intended construct

consistently. Furthermore, (Hundleby and Nunnally, 1968) suggest that a reliability coefficient above 0.70 is acceptable for research purposes, reinforcing the validity of the collected data.

3.9. Ethical Considerations

In conducting this research, utmost care was taken to ensure that no harm or oppressive practices were inflicted on men, women, children, or any other contributors. Instead, their contributions were acknowledged and treated with the highest respect. The research process was designed to minimize any potential risks or hazards to the community while striving to maximize its overall benefits. Every stage of planning and implementation adhered strictly to established ethical standards.

CHAPTER 4

4. RESULT AND DISCUSSION

4.1. GENERAL

This chapter deals with the analysis of the information's gathered from desk study, questionnaire and interview. It is structured according to the research objectives and questions and presents the findings and results of the survey, which focuses on Assessment of Road Asset Management practices and its challenges in Ethiopian Roads Administration. The desk study involved reviewing various documents related to road asset management practices, including methods of asset management, data collection processes, asset inventory, condition assessment, data management systems, and data integration. The data collected through questionnaires were analyzed using SPSS software and the results were discussed. Interviews were also conducted with management staff involved in Road Asset Management practice in order to deepen the findings of desk study and questionnaire. Accordingly, interpretation and discussion of the results are presented based on the findings. The complete set of survey questions used in this study is provided in Appendix A.

4.2. Desk Study

A desk study was selected as one of the methods to gather and evaluate data concerning the practices of Road Asset management from pertinent contract documents, magazines, reports, data, and other documents associated with road asset management practices, concentrating on the operations and experiences of the Ethiopian Roads Administration. The primary focus areas concerned for investigation encompassed the methods employed in road asset management by ERA, such as road maintenance by both own forces and private contractors, axle load control, road traffic surveys, asset inventory and data management systems, and road policy and strategies as discussed in the literature review parts in detail.

4.3. Questionnaire Response Rate

Detailed questionnaires were designed and disseminated for the assessment of Road Asset Management practices and its challenges in Ethiopian Roads Administration. In line with this purpose, questionnaires were distributed to the professional staff of Ethiopian Roads Administration who directly or indirectly involved in Road asset management. Even though 101 sample size determined for the distribution of questionnaires as shown in chapter three, only 75 were available at time and total of 75 questionnaires were distributed out of which, 61 (81%) questionnaires were filled and returned.

4.4. Quality of Respondents

Various experienced professional levels were targeted to fill the questionnaire survey. The summary of professional experience in the Area of Road asset management practice are shown below in the table 4.1.

Table 4-1 Professional level of Experience in Road Asset Management

Level of experience in the area	Number of respondents	Percentage (%)
1-5	20	32.8
5-10	26	42.6
5-15	10	16.4
15-20	2	3.3
>20	3	4.9
Total	61	100.0

As summarized in Table 4.1, the distribution of respondents across different experience levels reveals that the majority fall into the 5–10 years of experience category, representing 42.6% of the total. This is followed by respondents with 1–5 years of experience, who make up 32.8%. The remaining experience categories account for smaller percentages: 10–15 years (16.4%), 15–20 years (3.3%), and more than 20 years (4.9%).

Regarding educational background, 27.9% of the respondents hold an M.Sc. degree, while the majority, 72.1%, hold a B.Sc. degree as shown the table 4.2 belows.

Table 4-2 Educational Background of Respondents

Education background	Number of respondent	Percentage (%)
BSC	44	72.1
MSC	17	27.9
Total	61	100.0

In terms of the respondent’s position they hold at the time of the survey in the organization as shown above in table 4.3, about 4.9 % were at the top management managerial level (Road Asset Management Director or Manager) while 11.5% were at their middle managerial level (Road Asset Management Team Leader) and the remaining 83.6% are Road Asset Management Professional Engineer who directly participate in Road Asset management practice.

Table 4-3 Respondents Position at the time data collection

Respondent’s position	Number of respondent	Percentage (%)
Road Asset Management Director or Manager	3	4.9
Road Asset Management Team Leader	7	11.5
Road Asset Management Professional (Engineer)	51	83.6
Total	61	100.0

4.5. Questionnaire Response Analysis for Road Asset Management Practices and it’s challenges in ERA

4.5.1. Analysis to Questionnaire Related to Methods Road Asset Management

A. Familiarity with Methods of Road asset management practice

Based on the collected questionnaire and analysis conducted using SPSS data analysis, the results indicated that a significant majority of respondents, 86.9% (53 individuals), are fully familiar with the methods of technological integration in road asset management. Meanwhile, 13.1% (8 individuals) reported being partially familiar, while none of the respondents indicated a lack of familiarity or uncertainty as shown below in table 4.4. The presence of partial familiarity among some respondents indicates a potential need for further training and knowledge-sharing initiatives. As (OECD, 2020) notes, continuous professional development and the adoption of best practices from technologically advanced nations can bridge knowledge gaps and optimize road asset management strategies.

Table 4-4 Familiarity with Methods of Road asset management practice

Familiar with methods	Number of respondents	Percent
Yes, familiar	53	86.9
Partially familiar	8	13.1
No, Not familiar	0	0.0
I don’t know	0	0.0
Total	61	100.0

B. Methods and approaches of Road asset management practice

Regarding the description of methods and approaches used in ERA’s Road Asset Management Practice, 10 respondents (16.4%) indicated familiarity with the Own Force method. The majority, 38 respondents (62.3%), reported familiarity with a combination of all methods,

including Road Maintenance Contractors, Own Force, Private Contractors, Axle Load Control, and Road Traffic Surveys. Additionally, 10 respondents (16.4%) identified familiarity with a combination of Road Maintenance Contractors, Own Force, Axle Load Control, and Road Traffic Surveys. A smaller group of 3 respondents (4.9%) indicated familiarity with a combination of Road Maintenance Contractors, Own Force, and Road Traffic Surveys as described below in table 4.5.

Table 4-5 Methods and approaches of Road asset management practice

Methods of Road asset management practice	Number of Resopndent	Percentage
Road maintenance Contractor, Own force	10	16.4
Combination of the all method (Road maintenance Contractor, Own force, Private Contractors, Axle Load contro and Road Traffic survey)	38	62.3
Combination of Road maintenance Contractor, Own force, Axle Load control and Road Traffic survey	10	16.4
Combination of Road maintenance Contractor, Own force and Road Traffic survey	3	4.9
Total	61	100.0

C. Mostly (commonly) practiced method of Road Asset Management by ERA

Among the methods employed by the Ethiopian Roads Administration (ERA) for the preservation of road asset components, 43 respondents (70.5%) indicated that the 'Road Maintenance Contractor, Own Force' method is the most commonly practiced approach. Other combinations of methods are also utilized, as shown in Table 4.6 below.

Table 4-6 Mostly (commonly) practiced method of Road Asset Management by ERA

Methods of Road asset management practice	Number of Resopndent	Percentage (%)
Road maintenance Contractor, Own force	43	70.5
Combination of the all method (Road maintenance Contractor, Own force and Private Contractors	2	3.3
Combination of the all method (Road maintenance Contractor, Own force, Private Contractors, Axle	11	18.0

Load control, Road Traffic survey)		
Combination of Road maintenance Contractor, Own force, Axle Load control, Road Traffic survey	5	8.2
Total	61	100.0

The predominance of the 'Own Force' method underscores ERA's focus on leveraging internal capabilities for effective road management. This approach aligns with the organization's broader strategy to maintain control over maintenance activities and ensure the quality of road infrastructure. However, the limited adoption of combined methods suggests potential areas for enhancing road asset preservation practices.

To improve the effectiveness of road asset management, it is essential to consider a more integrated approach that combines internal resources with external expertise. A study titled "A road maintenance management strategy evaluation and selection model by integrating Fuzzy AHP and Fuzzy TOPSIS methods: The case of Ethiopian Roads Authority" proposes a model for evaluating and selecting road maintenance strategies. This model integrates Fuzzy Analytical Hierarchy Process (AHP) and Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods, offering a structured approach to decision-making in road maintenance management (Ayalew, Meharie and Worku, 2022).

D. Management System in Road Asset Management Practiced of ERA

Regarding the management systems currently utilized by the Ethiopian Roads Administration (ERA) in Road Asset Management, it was noted by respondents that several integrated management systems are highly practiced. These include the Highway Development and Management (HDM-4) tool, Pavement Management Systems (PMS), Bridge Management Systems (BMS), Road Safety and Traffic Management Systems (SMS), and Maintenance Management Systems (MMS).

E. Decision making levels defined in ERA’s Road Asset management practice

Findings from the questionnaire further reveal that ERA's decision-making processes are structured into clearly defined levels. These levels range from strategic decision-making to programming and budgeting, demonstrating a well-organized approach to managing road assets as shown below in table 4.7.

Table 4-7 Decision making levels defined in ERA’s Road Asset management practice

Decision making levels in ERA	Number of Resopndent	Percentage
Strategic level	7	11.5
Strategic level and Programming and budgeting level	8	13.1
Strategic level, Programming and budgeting level and Project selection level	2	3.3
Strategic level, Programming and budgeting level, Project selection level and Project level	32	52.5
Programming and budgeting level	5	8.2
Programming and budgeting level, Project selection level	2	3.3
Programming and budgeting level, Project selection level and Project level	5	8.2
Total	61	100.0

Strategic Level Decisions: A small portion of respondents (7 responses, 11.5%) identifies strategic decision-making as relevant. These decisions are typically high-level choices that shape the overall direction of the organization. Additionally, 5 responses (8.2%) pertain to decision-making at the programming and budgeting level.

The most significant portion of respondents, however, (32 responses, 52.5%) indicates that decision-making spans across all four levels: strategic, programming and budgeting, project selection, and project levels. This finding suggests a comprehensive approach where strategic, tactical, and operational decisions are interconnected.

Other combinations of decision-making levels are also observed, as noted above. The findings align with previous studies on road asset management frameworks, such as those outlined in World Bank (2018), which emphasize the importance of a structured yet adaptable decision-making approach in road infrastructure management. Similarly, research by OECD (2020) supports the notion that organizations with multi-level decision-making structures tend to exhibit higher efficiency in resource allocation and project execution.

Comparatively, road asset management practices in other countries, such as Australia and the UK, also follow a multi-tiered decision-making approach. For instance, Austroads (2021) highlights the importance of integrating strategic, financial, and operational planning to enhance

infrastructure sustainability. Unlike ERA, however, some international models place a greater emphasis on data-driven decision-making, leveraging advanced asset management systems for predictive maintenance and lifecycle cost analysis.

Overall, the analysis of ERA’s decision-making framework reveals a strong preference for a holistic, multi-level approach. This structure ensures that strategic directives are effectively translated into actionable plans, reinforcing the alignment between policy objectives and operational execution.

For other factors Respondents were asked to use Likert scales to indicate the degree of measure, implementation, importance, and/or effects for other factors that were described to assess Road Asset Management practice and the challenges of ERA. Five scales have been used to classify the level. Prior to beginning the analysis, each category was given a weighting: 5 for very high, 4 for high, 3 for medium, 2 for low, and 1 for very low. Following that, each respondent's responses were compiled and tallied.

The Statistic Package for Social Science (SPSS), which was used to enter the respondents' scores for each factor, helped with the analysis. As a result, the questionnaire responses were statistically analyzed to gain additional understanding. The analysis's findings are shown in Tables 4.8 to 4.10.

F. Road Asset Management Method and approach practiced in ERA

Table 4-8 Relative importance index (RII) and rank to measure the effectiveness of each Road Asset Management method in ERA

Road Asset Management Method	Time		Cost		Quality		Combined/ average/ RII	Rank
	RII	Rank	RII	RII	Rank	RII		
Road maintenance Contractor, Own force	0.68	1	0.61	2	0.61	2	0.63	2
Private Contractors	0.57	3	0.71	1	0.71	1	0.66	1
Axle Load control	0.56	4	0.61	2	0.56	3	0.58	4
Road Traffic survey	0.61	2	0.58	3	0.61	2	0.60	3

The table 4.8 above provides a comparison of different road asset management methods based on three essential performance indicators: Time, Cost, and Quality. Each method is evaluated using a Relative Importance Index (RII), which ranks their effectiveness in these areas.

Road Maintenance Contractor (Own Force): This approach ranks the highest for time efficiency, indicating that it is the quickest option available. Nonetheless, it displays moderate results in cost and quality, placing it second in both categories. The overall combined RII of 0.63 suggests a strong performance, making it a dependable choice for road maintenance.

Private Contractors: This method excels in both cost and quality, achieving the top rankings in these categories. Although its time efficiency is lower, the overall combined RII of 0.66 signifies that it offers the best balance between cost-effectiveness and quality. This finding aligns with global road asset management practices, where outsourcing maintenance to specialized contractors often results in better quality and cost efficiency, despite longer project timelines (World Bank, 2018).

Axle Load Control: This technique scores the lowest in terms of time efficiency and combined RII indicating that it is not a standalone solution for effective road asset management. However, its moderate scores in cost and quality suggest that axle load control remains crucial for preserving road infrastructure by reducing excessive damage from overloaded vehicles. Studies by OECD (2020) highlight that axle load control, when integrated with other asset management practices, extends road lifespan and reduces long-term maintenance costs (OECD, 2020), (OECD, 2000). This suggests it should be combined with other methods to enhance overall effectiveness.

Road Traffic Survey: This approach shows solid performance in time and quality, ranking second in both. However, its lower cost efficiency affects its overall positioning. Despite this, the combined RII suggests that road traffic surveys play a crucial supporting role in data collection and decision-making, which aligns with best practices in countries like the UK and Australia, where data-driven asset management is prioritized (Austroads, 2020).

In conclusion, the findings indicate that private contractors offer the best overall balance between cost and quality, making them the most effective long-term solution. However, own force maintenance remains the quickest option, useful for immediate interventions. Axle load control, while crucial for infrastructure preservation, should be integrated with other management strategies for greater efficiency. Meanwhile, road traffic surveys provide valuable data to enhance decision-making but require further cost optimization.

These findings align with international best practices, where a combination of outsourcing, preventive maintenance, and data-driven approaches leads to sustainable and cost-effective road asset management. Future improvements in ERA's road management system could focus on

enhancing contractor efficiency, increasing data integration, and adopting predictive maintenance models to ensure long-term infrastructure sustainability.

G. Asset Management System Component in ERA

Table 4-9 Relative Importance Index (RII) and Ranking for Implementing Each Asset Management System Component in ERA

AMS components	RII	Rank
Decision-Making Process (Level)	0.71	3
Organizational culture	0.69	4
Goals strategies and Policies	0.71	2
Condition survey assessments (Data management and inventory)	0.88	1
Performance monitoring	0.69	4
Alternative assessment and program optimization	0.65	7
System planning (Short and long range plan)	0.68	5
Program implementation	0.67	6

As shown above in table 4.9, the findings highlight that condition survey assessments rank as the most critical component of an effective Asset Management System (AMS), achieving the highest RII of 0.88. This suggests that accurate data collection, inventory management, and condition monitoring are the foundation for informed decision-making. Internationally, asset management frameworks emphasize data-driven approaches to optimize infrastructure maintenance and investment (World Bank, 2018).

Goals, Strategies, and Policies (RII = 0.71, Rank 2)- A well-defined policy framework ensures alignment between asset management activities and broader organizational objectives. This ranking is consistent with research by OECD 2020, which emphasizes policy-driven decision-making as a key success factor in long-term infrastructure planning (OECD, 2020).

In general regarding AMS components the findings reinforce that condition survey assessments are the most vital component of AMS, as data-driven decision-making supports all aspects of efficient asset management. Goals, strategies, and structured decision-making frameworks follow closely, highlighting the importance of policy alignment and governance. However, alternative assessments and program implementation rank lower, suggesting areas for improvement in optimization, predictive planning, and execution efficiency.

H. Prioritization Criteria in Road Asset Management Practice of ERA

The analysis of prioritization criteria in road asset management provides insights into the decision-making framework used by the Ethiopian Roads Administration (ERA).

Table 4-10 Relative importance index (RII) and rank to measure Prioritization Criteria in Road Asset Management practice of ERA.

Prioritization Criteria	RII	Rank
Road Class (Functional Classification)	0.84	1
Traffic Volume	0.84	2
Extent of Damage (Current Condition of the Road)	0.83	3
Road Maintenance History	0.71	4

As described above in table 4.10, the high Relative Importance Index (RII) values for road class and traffic volume suggest that ERA prioritizes roads based on their functional role and the demand they serve. This aligns with best practices in asset management, where heavily trafficked and functionally significant roads are given precedence due to their economic and social importance. Comparatively, studies conducted in other countries, such as the United States and European nations, have also shown a strong emphasis on these criteria. For instance, in the U.S., the Federal Highway Administration (FHWA) integrates traffic volume data with road classification to optimize maintenance schedules and investment decisions (FHWA, 2022).

Extent of damage, ranked third with an RII of 0.83, remains a crucial factor, reinforcing the need to address immediate structural issues. Many road management models, such as the Pavement Management System (PMS) in Australia, incorporate real-time condition assessments to ensure timely interventions (Austroads, 2019). The road maintenance history, though ranked lower with an RII of 0.71, still plays a role in decision-making. This relatively lower prioritization suggests that immediate physical conditions outweigh long-term maintenance trends in ERA’s approach. In contrast, some advanced road management systems, such as those used in Japan, integrate historical maintenance data extensively to improve predictive maintenance strategies (JICA, 2022).

This prioritization framework can effectively guide policymakers and transportation agencies in resource allocation, ensuring that critical roads receive the necessary maintenance to uphold safety and service levels. However, increasing the emphasis on historical data may enhance predictive maintenance capabilities, leading to more proactive and cost-effective road management strategies.

4.5.2. Analysis to Questionnaire Related to Technological Integration/Advancement in Road Asset Management practice

The data regarding the technological integration and/ advancement in road asset management, particularly the knowledge of technological equipment used in road asset management practice, was collected from sixty-one (61) participants. To assess the level of knowledge and awareness of available technological advancements/integration in road asset management, respondents were asked targeted questions, and the results are discussed below.

A. Awareness of Technological Equipment in Road Asset Management practice

Table 4-11 Awareness on Use of Technological Equipment

Category	Number of Respondent	Percentage (%)
Yes	55	90.2
No	3	4.9
I don't know	3	4.9
Total	61	100.0

As described above in table 4.11, among the respondents, 90.2% (55 individuals) were aware that ERA uses technological equipment for road asset inventory data collection, while 4.9% (3 individuals) were unaware, and 4.9% (3 individuals) were uncertain. This indicates a high level of awareness among professionals, suggesting that technology is integrated into ERA’s road asset management framework.

B. Types of Technological Equipment Used in Road Inventory

Table 4-12 Types of Technological equipment is used by ERA in the collection of Road asset inventory data

Type of Technological equipment	Number of Respondent	Percentage (%)
Automated	23	37.7
Automated and Semi- Automated	16	26.2
Automated, Semi- Automated and Remote data collection	8	13.1
Automated, and Remote data collection	4	6.6
Semi-automated	10	16.4
Total	61	100.0

As shown in the table 4.12 above, the respondents described the types of equipment used for road inventory that (37.7%) use of fully automated equipment, which highlighting a significant reliance on advanced technology for data collection, 16 respondents (26.2%) indicated the use of a combination of two specific equipment types (Automated and Semi-automated), 8 respondents

(13.1%) stated that they use a combination of three types of equipment (Automated, Semi-automated and Remote data collection system), 4 respondents (6.6%) responded the using a combination of two types (Automated and Remote data collection system) and 10 respondents (16.4%) indicated the use of semi-automated equipment only.

C. Usage of Automated Equipment in Road Asset Inventory Data Collection

Table 4-13 Employee Awareness on Usage of automated equipment in collection of Road asset inventory data

Category	Number of Respondent	Percentage (%)
Yes	16	26.2
No	21	34.4
Not used but I have observed equipment while collecting data	24	39.3
Total	61	100.0

As Described above in table 4.13 regarding the usage of the automated equipment in collection of Road asset inventory data as professional Engineer of Road Asset Management 16 respondents (26.2%) described as they have been used automated equipment whereas 24 respondents (39.3%) have answered as they have not personally used the equipment, have observed it being used during data collection and 21 respondents (34.4%) stated that they have not used automated equipment and all the respondents state that they are aware of as ERA use or have an established data base for Road asset system like Pavement and Bridge management system such as BMS and PMS. Despite varied levels of direct experience, all respondents acknowledged that ERA has an established road asset database, including Pavement and Bridge Management Systems (PMS and BMS).

In comparison with global best practices, the integration of automated and semi-automated technologies in road asset management is consistent with trends in developed countries. For instance: The United States Federal Highway Administration (FHWA) employs advanced automated road asset management systems using LIDAR, ground-penetrating radar (GPR), and satellite-based remote sensing for inventory updates and predictive maintenance (FHWA, 2021) and Australia’s Austroads integrates automated data collection tools with Geographic Information Systems (GIS) and Machine Learning for predictive analytics, ensuring proactive maintenance and cost-effective asset management (Austroads, 2020). This shows that Ethiopian Roads Administration (ERA) has shown a trend toward integrating road asset management tools into its practices to align with international standards and improve infrastructure management.

4.5.3. Analysis to Questionnaire related to current challenges in Road asset management practice of ERA

In order to assess current challenges in Road asset management practice of ERA, sixty one (61) respondents were asked three questions on the subject. All the respondents were aware of current challenges of Road asset management practice of ERA. From the described challenges the combination of challenges such as Shortage of resources like machinery and equipment, Shortage of construction material like Bitumen and Lack of Technologically advanced Road data collection equipment were the highest of from other challenges. These findings align with previous research on road asset management in Ethiopia. A study focusing on the Addis Ababa City Roads Authority (AACRA) identified similar challenges, such as organizational issues, financial constraints, political awareness, and professional competency gaps (Semunigus, 2020). Comparatively, road asset management practices in developing countries often face similar hurdles. A study published in the International Journal of Civil Engineering and Technology highlighted that developing nations frequently encounter challenges related to the implementation of asset management systems, including financial limitations, inadequate technological infrastructure, and insufficient training for professionals (Bhardwaj and Goswami, 2019). Addressing the challenges identified within ERA requires a multifaceted approach. Enhancing financial strategies, investing in technologically advanced equipment, and providing comprehensive training programs for professionals are essential steps toward improving road asset management practices. By learning from the experiences of both developing and developed countries, ERA can develop a more effective and efficient asset management framework to ensure the sustainability and reliability of its road infrastructure.

Besides to current challenges described above Road asset management components challenges level of effect were evaluated using likert scale to rank their effects as shown below in table 4.14. The analysis reveals that financial challenges are the foremost concern in road asset management, followed closely by political awareness and professional competency. These findings are consistent with challenges identified in road asset management systems in other developing countries. A study on the implementation of Road Asset Management Systems (RAMS) in developing countries emphasizes that financial constraints are a primary obstacle, often leading to inadequate maintenance and deterioration of road assets. The study also highlights the importance of political commitment and the development of professional competencies to effectively manage road assets (Bhardwaj and Goswami, 2019). Similarly, research focusing on RAMS in developing nations identifies financial limitations, lack of

political support, and insufficient professional expertise as critical challenges. The study suggests that addressing these issues requires a comprehensive approach, including securing sustainable funding, enhancing political awareness, and investing in capacity building for professionals involved in road asset management (Bhardwaj and Goswami, 2019).

Table 4-14 Relative importance index (RII) and rank to measure Road asset management components challenges

Road asset management components challenges	RII	Rank
Organizational culture (Organizational challenges) challenges	0.62	9
Decision-making process challenges	0.68	5
Organizational attention and ability how to manipulate asset data at an area or network level	0.66	7
Asset management awareness	0.68	6
Asset management knowledge	0.63	8
Financial challenges	0.85	1
Overall asset management system	0.70	4
Political awareness	0.73	2
Professional competency	0.71	3

4.6. Analysis to Interview Questions

In addition to desk studies and survey analyses, interviews were conducted with management staff from the Ethiopian Roads Administration’s (ERA) Road Asset Management Department. The purpose of these interviews was to assess ERA’s road asset management practices and the challenges faced in this area. Five interview questions were developed and presented to five management staff members, including two Directors and three Team Leaders.

The first interview question focused on evaluating ERA’s road asset management practices, specifically asking: “Does ERA have good road asset management practices? Why?” In response, the interviewees highlighted that assessing ERA’s road asset management effectiveness depends on multiple factors, including:

- Comprehensive Strategic Planning – Short and long-term planning that integrates road condition assessments and traffic data analysis,
- Road Asset Data Collection and Management - utilization of technology such as automated data collection tools and specialized asset management system, including PMS

(Pavement Management System), BMS (Bridge Management System), and ERAMS (Ethiopian Road Asset Management System), and others

- Road Maintenance and Preservation Strategies: Clearly defined criteria for road maintenance prioritization and execution,
- Stakeholder Engagement and Sustainability: Collaboration with key stakeholders to ensure sustainable road asset management practice.

The respondents collectively agreed that ERA has a well-structured and effective road asset management practice. Furthermore, they noted that ERA has established 10 Road Asset Management departments strategically located across different regions to enhance the efficiency of road asset management operations.

The second interview question asked for respondents was concerns, How would respondents characterize the improvements in cost, time, quality, and stakeholder satisfaction/feedback following the incorporation of Ethiopian Construction Works Corporation (Road Maintenance District) as ERA's organizational part that is currently conducting road asset management (Road maintenance)? According to the interviewees, the incorporation of ECWC into ERA has resulted in significant improvements across multiple areas:.

- a. Cost Efficiency: According to the reply, directly managing road assets lowers external contractor expenses and improves control, while combining maintenance tasks under ECWC to ERA in road management promotes cost efficiency by lowering outsourcing costs and provides better control over budgeting that leading to lower operational costs in the long term.
- b. Time Efficiency: According to the reply of respondent, ECWC's integration to ERA faster response times for quicker deployment of maintenance resources, leading to more timely repairs and preventive maintenance, which helps minimize road damage and interruptions and the integration reduced bureaucratic delays, enabling faster completion of projects.
- c. Quality Enhancement: According to the respondents, the integration of ECWC with ERA has led to the development of superior work standards because of a sense of ownership and direct supervision by internal experts, which provides better control over the quality of the materials and execution. Besides the respondents have added that, Road infrastructure's overall quality and longevity can be increased with a greater focus on prompt intervention, which will lessen the need for later, more involved repairs.
- d. Stakeholder satisfaction/feedback: According to the respondents, the integration of ECWC with ERA open a door for improved public feedback from Road users, including the general

public, companies, and transportation operators in such way that the two company considered as one to receive feedback easily and improved communication to engage stakeholders more effectively and handle complaints and ideas more quickly.

Overall, as the respondent stated the integration has likely enhanced efficiency, improved the quality of road infrastructure, reduced maintenance delays, and improved satisfaction among road users and other stakeholders.

Another interview question asked for respondents concerns with advantages of ERA for digitalizing Road information data and integrating them with different management tools such as PMS, BMS, GIS and Road Safety in Road Asset management practice. According to the interviewees, digitalization and integration of road asset information, using tools such as Pavement Management Systems (PMS), Bridge Management Systems (BMS), Geographic Information Systems (GIS), and road safety tools, offer numerous advantages to the Ethiopian Roads Administration (ERA) in its road asset management practices such as improved decision-making by having real-time and accurate data from systems to make decisions about maintenance priorities, investments, and resource allocation based on road conditions and performance metrics and also it helps to predict when roads or bridges will need maintenance or repairs, allowing for proactive rather than reactive management. Besides the respondents described that, Integrated data from GIS, PMS, and BMS allows ERA to allocate resources (labor, materials, equipment) more efficiently. Roads needing urgent repairs can be prioritized, preventing minor issues from turning into major, reduces operational costs such as manual reduce, paper-based processes, saving time and reducing administrative costs. The respondent emphasized that, by adopting these digital and integrated tools, ERA can optimize its road asset management practices, resulting in better performance, reduced costs, enhanced road safety, and improved stakeholder satisfaction.

The next interview question asked for respondents concerns with how decisions are made in ERA to finance a project maintenance or rehabilitation need or upgrading? According to the respondents reply, decisions regarding the financing of road maintenance, rehabilitation, or upgrading projects follow a structured process, involving technical, financial, and strategic assessments in the Ethiopian Roads Administration (ERA) which is generally aligned with national priorities, available funding, and the condition of the road network by following the procedure such as;

- Identification of Maintenance, Rehabilitation, or Upgrading Needs by undertaking Road condition assessment, stakeholder input and strategic importance

- Prioritization of Projects based on the data collected through asset management tools, traffic volume and economic impact of the road and safety concerns.
- Financial Analysis and Budget Allocation based on the conducted detailed cost estimation, available funding and value for money decisions are done.
- Review by ERA Management: after the Technical committee within ERA review the feasibility, technical aspects, and resource requirements of the proposed project with ERA's long-term road management strategy, ERA's management team, evaluates the projects based on priorities, strategic fit, and available budget and request approval from the Ministry or even higher governmental bodies if they have significant financial or policy implications.
- Financing and Procurement: after a project is approved, ERA works with the Ministry of Finance and relevant international partners to secure the necessary funds for implementation either of national budgets or international loans or grants, or public-private partnerships.

In summary the respondents described, ERA's decisions on financing road maintenance, rehabilitation, or upgrading projects are driven by a mix of technical assessments, financial considerations, and strategic priorities.

The final interview question asked for respondents concerns with major challenges that are affecting Road asset management practice in ERA. Accordingly, the respondent replied that, ERA currently faces several significant challenges that affect its road asset management practices which impacts the overall efficiency, sustainability, and quality of road infrastructure.

The major challenges described by respondents are:

- Limited financial resources and budget allocation imbalance:- Although there is substantial demand for road maintenance and rehabilitation, the available funding is often inadequate to cover the vast road network. Limited government budgets, donor dependency, and delays in securing international funding make it difficult to maintain road assets in optimal condition.
- Quality problem during Construction/ Upgrading:- Inconsistent Contractor quality problem during construction/ upgrading projects of outsourced to private contractors leads to substandard work that requires rework or more frequent repairs or prone to rapid deterioration become challenges to roads asset management.
- Road Maintenance Contractor Performance and Quality Control:- Contractor performance in road maintenance is often hindered by key challenges, including a lack of

machinery, where insufficient or outdated equipment limits efficiency and quality. Additionally, a shortage of skilled manpower reduces productivity and increases errors. The aging of construction machinery further exacerbates issues, as declining efficiency, frequent breakdowns, and rising maintenance costs strain resources. Outdated equipment also fails to meet modern quality standards, leading to inconsistent and results as described by the respondents.

- The respondents described others challenges such as Lack of coordination within an organization, rapid urbanization and traffic growth, weak digital tool implementation and data gaps, political instability/ security issues, lack of public awareness and engagement in Road Asset management, Procurement delays to outsource Road Maintenance project.

Finally, the respondent stated that, Addressing these challenges will require strategic planning, enhanced funding mechanisms, capacity building, and stronger institutional coordination to improve road asset management practice.

CHAPTER 5

5. CONCLUSION AND RECOMMENDATION

5.1. General

This study assessed road asset management practices and challenges in the Ethiopian Roads Administration (ERA) based on three specific objectives: identifying methods of road asset management, examining technological practices, and identifying current challenges affecting road asset management. In view of the above, the following conclusions and recommendations are therefore presented.

5.2. Conclusions

The following conclusions were developed based on the findings of the study

- ERA employs various methods, including the "Road Maintenance Contractor Own Force" approach, private contractors, axle load control systems, and road traffic surveys. Road Maintenance Contractor Own Force" method is the most commonly practiced, particularly for routine and emergency maintenance and offer timely response in asset management practice. Private contractors contribute significantly to construction/rehabilitation/ and periodic maintenance, offering cost-effective and high-quality services whereas it's effectiveness is not satisfactory with respect to time as determined from analysis of questionnaire. Axle Load Control and road traffic surveys also aid in asset management by incorporating their data as input for road maintenance and/or rehabilitation/construction.
- ERA utilizes tools such as, ERAMS, HDM-4, PMS, and BMS; however, the integration of advanced technologies like automated equipment, including Hawkeye 1000, Hawkeye 2000, and the Falling Weight Deflectometer (FWD), for road condition assessment and inventory management remains limited. Data collection and analysis are still predominantly conducted through manual procedures. The lack of sufficient automated equipment restricts ERA's ability to optimize maintenance strategies and make efficient, data-driven decisions.
- The major challenges affecting road asset management practices in ERA include financial constraints, organizational issues, and a lack of political awareness. Additionally, weaknesses in the overall asset management system and limited professional competency further worsen the situation. capacity of road maintenance contractor, Performance and quality control issues with road maintenance contractors, as

well as quality problems during construction and upgrading, are also significant contributors to the challenges faced by ERA.

5.3. Recommendations

The following suggestions are offered for policy makers at ERA and at the governmental level concerning the practices and challenges of road asset management practice.

- For the effective asset management the integration of road asset management methods such as Road Maintenance Contractor Own Force, private contractors, axle load control systems, and road traffic surveys shall be enhanced.
- To enhance the effectiveness of road asset management practices, it is recommended to strength the capacity of the Road Maintenance Contractor Own Force through targeted capacity-building initiatives
- Equip vehicle axle load control systems with advanced technological tools for accurate data collection and analysis.
- Introduce a centralized and automated data management system to optimize data collection, storage, and analysis, ensuring consistency and ease of access.
- Establish standardized processes and guidelines for road asset management across all departments to guarantee uniformity and quality in practice.
- Allocate resources towards modern technologies for advanced road asset management, including automated vehicle-mounted laser systems, Geographic Information Systems (GIS), and robotics for conducting road asset condition and for others road asset components.
- Create training initiatives to improve technical proficiency in the use of contemporary tools such as ERAMS, PMS, and BMS for informed decision-making and resource distribution.
- Implement comprehensive training programs for ERA staff, particularly within the road asset department, which involve both direct and indirect participation in road asset management, to enhance their skills in areas such as data management, condition assessments, and strategic planning via workshops and seminars that conducted by experts in the area of road asset management.
- To mitigate financial limitations, it is essential to advocate for enhanced funding and investigate public-private partnerships to guarantee the sustainable maintenance and development of road infrastructure.

- Implement more performance-based contracts, establish comprehensive quality control standards, and create systems for ongoing monitoring and evaluation of contractor performance to address quality issues.
- Cultivate a collaborative organizational environment that encourages stakeholder involvement and facilitates cross-functional cooperation.
- Create a comprehensive decision-making framework that incorporates strategic, tactical, and operational levels to ensure coherence across all management tiers.
- Enhance institutional frameworks by promoting a culture of accountability, improving coordination between departments, and aligning organizational objectives with strategic goals for road asset management.
- Foster a culture of continuous improvement: Encourage ongoing learning and enhancement within the organization by rewarding innovative strategies and acknowledging staff contributions to effective asset management practice.
- The draft Road Sector policy developed by ERA shall be officially published and ratified to reinforce legal frameworks and regulatory measures within the road sector.

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APPENDIX A



JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR
MSC. IN CONSTRUCTION ENGINEERING AND MANAGEMENT

INFORMATION FOR RESPONDENTS

Dear participants;

The questionnaire is prepared by Construction Engineering and Management post graduate student for conducting research on **Assessment of Road Asset Management Practices and Its Challenges: A Case of Ethiopian Roads Administration.**

The aim of this questionnaire is to assess the road asset management practice and its challenges in the case of Ethiopian Roads Administration, Road Asset Management. This questionnaire is required to be filled with exact relevant facts as much as possible. The information will be used for academic purposes only. Your answers will be kept completely confidential. It will be collected and presented as summaries only. The compiled results of this research may be published in scientific research journals or presented at professional conferences. Therefore, your honest response is very much important input to my thesis. The attached questionnaires are developed based on literature reviews. You can **tick, write in words or rank** on the space provided.

If you have any questions/queries please do not hesitate to contact me on:

- +251-921277485
- jenberutadesse@gmail.com

Thanks a lot for your time and assistance!!

Part one: - Personal Information

- 1. Gender: Male Female
- 2. Age 18-25 26-35 36—45 46-50 Above 50
- 3. Education background
 - Level-3 Level-5 BSc/BA
 - Level-4 Diploma MSc/MA
- 4. Level of experience in the area (Work experience in Road asset management)
 1-5 5-10 10- 15 15-20 >20
- 5. Respondent’s position
 - Road Asset Management Director or Manager
 - Road Asset Management Team Leader
 - Road Asset Management Professional (Engineer)
 - If other specify-----

Part Two: - Questionnaire Related to Methods Road Asset Management

This part of the questionnaires is provided to collect data from staff member of Ethiopian Roads Administration Road Asset Management Professionals under different position and participates in Road asset management practices in operation and maintenance phases.

- 1. As a professional staff of Ethiopian Roads Administration, are you familiar with methods of Roads administration that practiced by your organization?
 - a) Yes, familiar b) No, Not familiar c) Partially familiar d) I don’t know
- 2. What are the methods that ERA’s use in its Road asset management practice? (please check all that apply)
 - a) Managing Road asset by Road maintenance Contractor (Own force, Road asset maintenance Contractor)
 - b) Managing Road asset by Private Contractors
 - c) Managing Roads Asset resources from damage by establishing Axle Load control
 - d) Conducting Road Traffic survey to determine the Traffic Volume along the Route
 - e) Others if any specify

.....

3. From ERA's methods of Road asset management which one is/ are mostly (commonly) practiced in preservation of road asset components? (please check all that apply)
- a) Managing Road asset resources by Road maintenance Contractor (Own force, Road asset maintenance Contractor)
 - b) Managing Road asset by Private Contractors
 - c) Managing Roads Asset resources from damage by establishing Axle Load control
 - d) Conducting Road Traffic survey to determine the Traffic Volume along the Route
 - e) Others if any.....
4. Time, cost and quality are the most common measure of level of service in evaluating of methods of Road asset management practice. Please rate their level of effectiveness (measure) as shown below in ERA's methods road asset management practice.
- Low – 1
 - Medium – 2
 - High -3
 - Very high -4

Road Asset management methods	Level of measure														
	Time					Cost					Quality				
	Very Low	Low	Medium	High	Very high	Very Low	Low	Medium	High	Very high	Very Low	Low	Medium	High	Very high
Road maintenance Contractor (Own force, Road asset maintenance Contractor)															
Private Contractors															
Axle Load control															
Conducting Road Traffic Survey															

5. Road Asset management system components are one of the components that are used to evaluate **methods of Road asset management practices in ERA**. Please rate their level of implementation as shown below.

- Very low -1 Low – 2 Medium – 3 High -4 Very high -5

AMS components	Level of implementation				
	Very low	Low	Medium	High	Very high
Decision-Making Process (Level)					
Organizational culture					
Goals strategies and Policies					
Condition survey assessments (Data management and inventory)					
Performance monitoring					
Alternative assessment and program optimization					
System planning (Short and long range plan)					
Program implementation					

6. Please check the management systems that ERA is currently using in methods Road Asset management (Please check all that apply)

- a) Highway Development and Management (HDM 4) Tool.
- b) Pavement management systems (PMS).
- c) Bridge management system (BMS)
- d) Road Safety and Traffic management systems (SMS).
- e) Maintenance Management systems (MMS).

7. What are the decision making levels that have been explicitly defined in ERA’s methods Road asset management practice (please check all that apply):

- a) Strategic level (i.e., concerning policy of decisions for the overall network).

- b) Programming and budgeting level (i.e., concerning overall resource allocations for design, maintenance and rehabilitation throughout the entire network).
 - c) Project selection level (i.e., selection of individual projects or groups of projects for funding and/or implementation)
 - d) Project level (i.e., design concerning specific treatments or actions for the selected projects).
 - e) Don't know what decision levels are defined.
8. Does ERA apply all types of maintenance methods like preventive, routine, periodic, heavy maintenance and rehabilitation based on the data collected?
- a) Yes b) No c) Planned d) I don't know
9. One of the method that practiced by ERA in its Road asset management practice is prioritization of projects that are candidates for funding and implementation. Please rate the following prioritization criteria based on their level of importance for Road asset management practice:

Prioritization Criteria	Level of importance (prioritization)				
	Very low	Low	Medium	High	Very high
Road Class (Functional Classification)					
Traffic Volume					
Extent of Damage (Current Condition of the Road)					
Road Maintenance History					

Part Three: - Questionnaire Related to Technological Advancement in Road Asset Management practice

1. Do you know that ERA use (incorporate) Technological equipment in its Road asset inventory data collection in Road asset management practice?
- a) Yes b) No c) I don't know
2. What is the technological equipment that is used by ERA in the collection of Road asset inventory data? (please check all that apply):
- a) Automated (using of vehicle equipped machine and/ or storage device that record road inventory information with video cameras)
 - b) Semi-automated

- c) Remote data collection system (Global Navigation Satellite System)
 - d) If others please specify.....
3. Have ever used the automated equipment in collection of Road asset inventory data as professional Engineer of ERA?
- a) Yes b) No c) not used but I have observed equipment while collecting data
4. If your answer for question number 3 above is yes or not used but I have observed the automated equipment while collecting data, please list the type of Automated equipment you have used or observed ?
- -----
5. Does ERA use or have an established data base for Road asset system like Pavement and Bridge management system that you know? (Please check one)?
- a) Yes, it already has Road Asset System Management database.
 - b) No, it does not have Road Asset System Management database.
 - c) It is planning to develop Road Asset System Management database
 - d) I don't know
6. If your answer for question number 5 above is yes, please list the type of database that used in Road asset system management that you know?
- -----
7. In modern Road asset management practice one of the criteria is integration of Road asset management system. Is there a trend of integration of Road asset management tools in ERA, Road asset management Practice that you know?
- a) Yes
 - b) No
 - c) I don't know
8. If your answer for question number 7 above is yes, please list the components of Road asset system management that integrated to each other?
- -----

Part Four: - Questionnaire related to current challenges in Road asset management practice

1. Are there any challenges that are currently affecting ERA's Road asset management practices?
 - a) Yes
 - b) No
 - c) No major challenges

2. What are the challenges that are happening now in ERA Road asset management practice? (Please check all that apply):
 - a) Shortage of resources like machinery and equipment
 - b) Shortage of construction material like Bitumen
 - c) Lack of training for professional
 - d) Lack of professional trained in the field of Road asset management
 - e) Lack of manual and guide line in digital data collection
 - f) Lack of Technologically advanced Road data collection equipment

3. Please rate the following challenges arising in Road asset management practices according to their level of effects

Road asset management components challenges	Level of effects				
	Very low	Low	Medium	High	Very high
Organizational culture (Organizational challenges)					
Decision-making process					
Organizational attention and ability how to manipulate asset data at an area or network level					
Asset management awareness					
Asset management knowledge					
Financial challenges					
Overall asset management system					
Political awareness					
Professional competency					

INTERVIEW QUESTION

1. Do you think that ERA has a good Road asset management practice? Why?
2. To improve Road asset management practice of Ethiopian Roads Administration, Ethiopian Construction Works Corporation (Road maintenance District) was incorporated as part of ERA’s organizational part and it’s currently undertaking Road asset management (Road maintenance) by itself. How do you describe the improvements that have been gained in terms of cost, time, quality and Stakeholder satisfaction/ Feedback then after? Please describe level of improvement gained briefly.

3. ERA as part its reform is working on digitalizing Road information data and integrating them with different management tools such as PMS, BMS, GIS and Road Safety. What are the advantages of using such digitalization and integration of Road asset information as method in Road Asset management practice?

4. How decisions are made in ERA to finance a project maintenance or rehabilitation need or upgrading?

5. What are current challenges that are affecting Road asset management practice in ERA? (Major challenges?)
