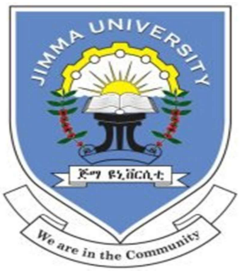

JIMMA UNIVERSITY
JIMMA INSTITUTE OF TECHNOLOGY
SCHOOL OF GRADUATE STUDIES
FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING
CONSTRUCTION ENGINEERING AND MANAGEMENT CHAIR

ASSESSMENT OF THE FACTOR AFFECTING THE PRODUCTIVITY OF EARTHWORK EQUIPMENT IN ADDIS ABABA CITY ROAD AUTHORITY PROJECTS

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

Feven Fekede Tamiru

February 2020
JImma, Ehtiopia

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Advisor: Engr. Bein Maunahan(Asst prof) SIGNATURE

Co-Advisor: Dr. Lucy Feleke SIGNATURE

February 2020
Jimma, Ethiopia

DECLARATION

I declare that this research entitled **"**Assessment of the factors affecting the productivity of earthwork equipment in Addis Ababa City Road Authority projects" is my own original work and has not been submitted as a requirement for the award of any degree in Jimma University or elsewhere.

Feven Fekede Tamiru _____ _____

NAME SIGNATURE DATE

As research Adviser, I hereby certify that I have read and evaluated this thesis paper prepared under my guidance, by Feven Fekede Tamiru entitled "ASSESSMENT OF THE FACTOR AFFECTING THE PRODUCTIVITY OF EARTHWORK EQUIPMENT IN ADDIS ABABA CITY ROAD AUTHORITY PROJECTS" and recommend and would be accepted as a fulfilling requirement for the Degree Master of Science in Construction Engineering and Management.

Advisor: Engr. Bein Maunahan(Asst prof) _____ _____

NAME SIGNATURE DATE

Co - Advisor: Dr. Lucy Feleke _____ _____

NAME SIGNATURE DATE

DECLARATION

This research is my original work and has not been presented for a degree in any other university.

Feven Fekede	_____	_____
Researcher	Signature	Date
Engr.BeinMaunahan(Asstprof)_____		_____
Advisor	Signature	Date
Dr. Lucy Feleke	_____	_____
Co-Advisor	Signature	Date

Approved by Board of Examiners

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External Examiner	Signature	Date
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Internal Examiner	Signature	Date
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ABSTRACT

Construction is one of the major economic sectors through out the world. The sector consists different mega structures in which varaitey of heavy duty machines and equipments are used during the course of the construction. Construction of road projects is one of the sector where different heavy duty equipments is utilized for execution of the work. However, the construction of many road projects is refrained due to multifaceted problems encountered in the course of construction. Equipment productivity is one of the significant factors affecting the successful completion of a project. Though the factor affecting equipment productivity in road construction cannot be avoided, they can be minimized by adequately identifying the factors that cause loss of equipment productivity in road construction projects. We all dream of a road construction project completed with the specified scheduled time and budget, but usually, it is not achieved due to several factors that affect the project. The general objective of this study is to assess the factors affecting the productivity of earthwork equipment in Addis Ababa City Roads Authority. The research works briefly to determine the factors affecting earthwork equipment productivity in Addis Ababa City Roads Authority Projects by checking the efficiency of earthwork equipment productivity. Moreover, it assesses the effect of earthwork equipment efficiency on the progress of a road project. The research method used is a purposive sampling. Questioners, critical observation, and focal group discussion are the tools used in collecting the data. Based on the collected data and the analysis made, the research identified the following factors as the factors affecting earthwork equipment productivity. These are Environmental Factor, Management Factor, Operator Factor, Equipment Factor and Technical Factor Moreover, efficiency of the equipments is calculated to check the productivity of the equipments and to identify the factor for loss of productivity.In the research, inorder to enhance equipment productivity proper supply of spare parts for the equipmentst, providing of trainee to the management staff and operators, providing of incentive and recognition to the project staff , updating technical knowledge of the operator ,and systematic organization of the garage and the equipment adminstrtation is recommeneded.

Key Words: *Earthwork, factors, equipment productivity, road construction*

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ACRONYMS

AACRA	Addis Ababa City Road Authority
CEM	Construction Engineering and Management
EW	Earthwork
EWE	Earthwork Equipment
GDP	Gross Domestic Product
JIT	Jimma Institute of Technology
JU	Jimma University
R	Rank
RII	Relative Importance Index
SPSS	Statistical Package for Social Science

CHAPTER 1
INTRODUCTION

1.1Background of Study

The construction industry makes significant contributions to the socio-economic development process of a country. The industry plays a vital role in most of the developing countries. This is mainly because developing countries are considerably dependent on the growth and development of their physical infrastructures and because the linkage of the construction industry to both economic and social sectors is very significant [1].

The construction industry makes significant contributions to the socio-economic development process of a country. The construction industry has essential contributions to the Ethiopian economy, as demonstrated by its share in the GDP. For instance, the share of the sector in the total GDP averaged at about 5.2 percent in the period 2002/03-2006/07 The sector has registered relatively higher growth as compared to the growth of GDP during this period. Over this period, there has been an increased investment in the development and expansion of various infrastructure projects like roads, airports, and residential and non-residential housing units [2]. Hence, improving the productivity of this industry will result in achieving lower construction costs and thus higher profit, which may translate into higher wages and an ultimately higher standard of living.

The aim of every construction project sector is the completion of a project that meets the objective of time, cost, and quality. However, the industry suffers from no problems that affect time, cost, and quality performances [3].

In the construction industry, a different type of equipment and machinery is used depending on the nature and type of the project. The dependence and need for heavy construction equipment have grown with the size and complexity of construction projects [4].

Construction equipment productivity is one of the main drivers for completing projects within stipulated time and cost [5]. Low productivity will affect the efficiency of the equipment which results in unnecessary extra cost to the project. Proper equipment

management can increase equipment productivity, which leads to reduce the overall cost of the project [6].

In a road project, equipment cost is high, which affects the overall cost of the construction project. Being able to utilize the workforce and equipment effectively can improve productivity, reduce costs, and make efficient use of resources for road construction [7].

In road construction, earthwork is one of the significant tasks to be accomplished. The task consists of roadway excavation works, borrow material production, cut to fill, and borrow to fill works. Different heavy types of equipment like dozer, excavator, grader, loader, roller dump trucks, and shower truck is used for executing this activity. To achieve the success of the project within cost and time will require adequate planning and implementation of the earthwork activities [8].

The performance of earthmoving operations contributes considerably to the success or failure of construction projects [9]. Knowing the impact and the extent of loss of construction equipment productivity will safeguard the contractors and the client of the projects from time and cost overrun resulted from the poor performance of the construction equipment.

Low productivity of equipment, which is caused due to an idle hour or down hour of equipment is the main reason that affects the successful completion of a project in time and cost. To avoid the low productivity of earthwork equipment and to maximize their output, it is essential to identify the factors that affect the productivity of earthwork equipment and machinery.

According to [10], the weak performance of construction equipment productivity is contributed by many factors. Besides, identification and evaluation of factors affecting Construction equipment productivity in many construction projects is also very weak. Moreover, there has been a lack of research in our country concerning the assessment of loss of equipment productivity and factors contributing to low productivity. Hence, the primary benefit of this study is to provide the contractor and client scientific knowledge on the factors affecting the productivity of earthwork equipment and to recommend how to improve the productivity of types of equipment.

This study focuses on identifying the factors affecting the productivity of earthwork equipment. The research is conducted on asphalt road projects which are under

construction in Addis Ababa City. The owner/ employer of the projects is Addis Ababa City Roads Authority.

1.2 Statement of the Problem

Construction productivity, which is measured by output per unit of resource input, plays a crucial role in the success of a construction project [11].

Ethiopia is investing a tremendous amount of money for the construction of megaprojects. Many new asphalt concrete road projects are conducted in the country. Besides, the government is working intensively on the upgrading of the existing ones.

Despite the high importance of the construction sector in Ethiopia, the industry suffers from many problems that affect time, cost, and quality performances. The first potential weakness is that contractors never build the same project under the same working conditions with the same resources. The main reason is that equipment does not have consistent productivity. Moreover, the actual hourly production of equipment differs from the nominal hourly production provided by the manufacturers [12]. As a result, a wide range of performance levels observed during operation. Therefore, it is essentially crucial to asses and understands the factor affecting equipment output for the smooth and successful accomplishment of a project.

This study aims to identify the factor affecting the output of earthwork equipment in asphalt road projects.

1.3 Research Questions

- What are the factors affecting earthwork equipment productivity in Addis Ababa city road authority projects?
- What is the efficiency of earthwork equipment in Addis Ababa city road projects?
- How will equipment efficiency affect the progress of a road project in Addis Ababa city?

1.4 Objective of Study

1.4.1 General Objective

The general objective of this study is to asses the factors affecting the productivity of earthwork equipment in Addis Ababa City Roads Authority.

1.4.2 Specific Objectives

- To determine the factors affecting earthwork equipment productivity in Addis Ababa city road authority projects.
- To check the efficiency of earthwork equipment in Addis Ababa road projects.
- To determine the effect of earthwork equipment efficiency on the progress of the road project in addis ababa.

1.5 Scope of the Study

This study was conducted on road projects under construction in the Addis Ababa City Roads Authority project. Also, this study focused on the factors affecting the productivity of earthwork equipment, particularly focused on borrow production of the road project used equipment dozer and excavator, on the selected projects. Proper data were collected from professionals and skilled human resources working in the project with interviews and questioners.

Moreover, actual data is collected to check the efficiency/ availability of the types of equipment. Four projects are selected from a total of 13 projects to check the actual output of types of equipment. Proper data is collected for three days of operation time to check the efficiency of the equipment and identify the reason for the loss of efficiency.

1.6 Significance of the Study

Understanding the factors and tackling the problem is critical to improving the productivity of earthwork equipment. The productivity of construction equipment benefits the client, contractor, and the public at large.

The significance of the research is to assist the contractor in identifying the factors affecting the productivity of earth work equipment and in increasing the productivity by giving remedial measures to the contributing factors. This will help the contractor to accomplish project activities within the scheduled time and budget. Moreover,

unnecessary equipment costs that might be incurred from the low productivity of types of equipment will be avoided. Concerning the socio-economy of the country, it will accelerate project accomplishment by enhancing equipment productivity and avoiding the causes for low production.

The findings of this study will help the project managers in the planning stage for the allocation of equipment in a project site. Moreover, Professionals working in construction projects which are mainly engaged in initial phases of construction planning will deliver the project plan efficiently.

The study is helpful for further researches to be conducted on construction management on road construction in other areas of Ethiopia. The findings of the study will give the stakeholders detail information on the factors affecting equipment productivity in road construction in Addis Ababa city road authority projects.

CHAPTER 2

LITERATURE REVIEW

The construction sector is one of the world's largest and challenging industries [13]. The tremendous amount of money is allocated in the industry for the construction of megaprojects. Road projects are one of the mega projects which are widely constructed throughout the world.

In road projects, a large amount of the project cost is accounted for equipment and machinery. Equipment can be used at every phase of construction like excavation, compaction, leveling, hauling, grading, etc [14].

Road construction is the primary sub-sector which takes the lion's share of construction expenditure on the construction industry of Ethiopia. The share of road sector expenditure in the total government construction expenditure was 49.5 percent, 44.5 percent and 48.4 percent in 2003/04, 2004/05 and 2005/06, respectively, overall accounting for nearly half of the expenditure of government expenditure on construction. This was due to the high priority accorded to road construction in the country [2].

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2.1 Earthwork Equipment Productivity

2.1.1 Earthwork Equipment

Every construction work starts with earthmoving operations during its initial phase. In earthwork operation, different types of equipment are allocated for excavation and filling works. Heavy construction equipment is routinely used in a construction project that entails earthmoving operations [8].

The rapid development of the construction industry in recent years and the magnitude of the present-day constructions involved the movement of a large number of earth excavations, [8].

Earthmoving operations and highway construction commonly entail extensive utilization of heavy construction equipment [15]. The operations are highly equipment-driven processes, and the equipment costs constitute a significant part of the investment and operating cost [16].

Every process in construction is strictly connected with costs and deadlines which have to be met by the investor/owner and the construction company. Equipment usage will give fast and accurate results at a reduced cost [17]. The efficient utilization of equipment is considered a crucial element towards the success of the earthmoving project. However, various factors affect, directly and indirectly, the efficient utilization of equipment and subsequently can lead to productivity decline in earthmoving operations [15].

In general, the most frequently assigned equipment for earthworks activities are dozers, scrapers, wheel loaders, grader, excavators, haul trucks, and compactors. Earthworks are a fundamental part of heavy construction engineering and involve the moving and processing of the soil surface of the earth. Typically, earthmoving operations are carried out during the early stages of substantial construction projects [16].
In road projects, earthwork is one of the significant tasks of the project with the high cost of the contract amount. The task consists of the significant activities below

- Production of borrow material
- Excavation of roadway for cut section
- Placing of borrow material for fill section
- Hauling of borrow material to fill section and waste material from cut section to spoil area.

The task comprises heavy-duty equipment like

- Dozer and excavator for production of borrow material and excavation works
- Grader, roller and shower truck for placing of borrow material
- Loader and dump truck for loading and hauling of material

This research focuses on earthwork types of equipment engaged in borrow material production works. According to ERA Technical Specification and from experience in AACRA Projects, the equipment used for excavation and borrow material production are dozer and excavator.
Excavators - are primary earthmoving machines and equipment used to excavate earth and related materials [27].

Dozer - A tractor equipped with a front-mounted earthmoving blade. A dozer moves earth by lowering the blade and cutting until a full blade load of material is obtained. It then pushes the material across the ground surface to the required location.

2.1.2 Definition of Productivity

There are many definitions used to define productivity. International Labor Office (Mostafa, 2003, cited in Melese, M,2016) [18] described productivity as "Productivity is a comparison between how much you have to put into the projects in terms of workforce, material, machinery or tools and the result you get out of the project. Productivity has to do with the efficiency of production. Making a site more productive means getting more output for less cost in time, Productivity covers every activity that goes into completing the construction site works, from the planning stage of the final site clearing, if the contractor can carry out these activities at lower cost in less time with fewer workers or with less equipment the productivity will be improved".

Productivity can be defined as the output over input that indicates the efficiency of a productive system. It ensures optimal use of the resources involved in the system, as well as the smooth and uninterrupted flow of the process [19].

2.1.3 Earthwork Equipment Productivity in General

The output of any equipment per minute, hour, or day is called the productivity of the equipment [6]. In an earthmoving operation, productivity is defined as the total output from the entire fleet, *i.e.,* transported material in a ton or m^3 per operating hour.

Productivity is one of the essential aspects of Project Management and it makes or breaks a project. Construction equipment productivity is one of the main drivers for completing projects within stipulated time and cost. To improve productivity, we must be able to make changes in methods, operation strategies, and systems.

The research conducted in Iran by the [12] show The actual hourly production of the equipment can effectively contribute to the management of the construction projects.

According to [20], the success of a construction project is highly connected to its machinery production, and it has been universally accepted that the hourly machinery production is the crucial factor in the success of construction projects.

Productivity has always been noted as one of the most critical factors affecting the success and overall performance of every organization [21].

The low productivity in the construction industry has long been a significant concern, and several studies have been focused on the identification of productivity factors [22].

2.1.4 Efficiency of Earthwork Equipment

The completion of any project's success depends on the efficient utilization of resources assigned for the project. However, the construction sector suffers from several problems that affect time, cost, and quality performances. The analysis of the survey indicated that among the top risks affecting time overrun in road construction projects in Palestine is lack of equipment efficiency [3].

Efficiency is simply the ratio of actual productivity divided by the estimated productivity. This ratio allows the project manager to compare the estimated productivity with actual productivity [13].

Estimating onsite productivity is a difficult task that requires tracking heavy and costly equipment and requires collecting, managing, and analyzing a considerable amount of data from construction sites on daily bases [23].

In this research, equipment efficiency is calculated based on the utilization of the equipment per hour.

$$EE = OP/WH*100$$

$$WH = OP+ID+DW$$

Given that

EE = Equipment Efficiency, OP = Operational Hour, ID = Idle Hour, DW = Down Hour

2.2 Factors Affecting Productivity of Earthwork Equipment

The overall productivity of construction is affected by various reasons. The downtime and the idle run time of equipment play an important role in the production. These downtime & idle time factors will affect the total cost of the project [24].

The low productivity in the construction industry has long been a significant concern, and several studies have been focused on the identification of productivity factors [22].

According to (nipin joseph babu) among 10 different factors that affect the success of construction projects, productivity factors are ranked fourth [25].

For effective equipment management, it is necessary to study the productivity or output of equipment. To find out the productivity of equipment, the study of factors affecting them is necessary [6].

Understanding the factors affecting the productivity of equipment is supportive for construction experts who work on all venture stages, particularly on the starting stage of construction planning, in order to effectively provide project plans [26].

2.3 Review of Factors Affecting Productivity of Earthwork Equipment

Different researchers find many different factors that may affect the productivity of the equipment. According to Sachin Pindoria [35], factors are identified as a critical factor affecting the productivity of construction equipment. Based on their detailed literature review, these factors are identified and classified into four different groups. These are Soft Factors, Hard factors, Controllable factors, Uncontrollable factors that affect the productivity of construction equipment. Moreover, it is concluded that proper handling of these factors can improve the productivity of equipment as well as construction by increasing the productivity and minimize the total cost of the project [6].

The study showed that all the three groups-clients, consultants and contractors of participants generally agreed that out of a total of 29 factors the top 10 influencing factors affecting equipment productivity are: Rework, Lack of experience, Implementation of standards, government laws & regulation payment delays, Lack of supervision, Availability of required equipment, Disloyalty, Lack of required construction materials or/and price increase. Permits delays from authorities. Intricate designs in drawings. Incomplete drawings [13].

It was found that 10 factor which affect equipment productivity in construction project such as Lack of ability of operator, Rework, Lack of supervision, Improbable planning and expectation of labor execution, Delay in placing the equipment, Two or more groups sharing an equipment, Communication between site administration and operator, Equipment breakdown, Lack of proper maintenance and Non- payment of charges/Delay in payment [26].

[5] Studied about factors influencing the productivity of construction equipment on site. The survey results show that the Equipment's efficiency and proper attachment affect the productivity of the equipment on a large scale than any other factor taken for the survey.

Some of the common factors that can affect the performance of excavating equipment are:- 1) Incorrect equipment selection may directly affect its productivity for that particular Work.2) Excavation is generally faster for soft soil as compared to hard strata. 3) The greater angle of swing results in more excellent cycle time which may lead the work to delay. 4) Time saved per cycle is nothing if the operator's skill is poor. 5) Regular repairs and maintenance of equipment may increase its life, providing better performance [8].

Hoe productivity as it relates to cycle times, it is possible to gain a second here and a few milliseconds there, but if the excavator does not have the operator trained adequately, then all the efforts are wasted. Putting the truck in the right position also saves time for the operator If the backhoe is set up correctly with the truck on the lower level with a low swing angle say 300 to 400 the cycle time could as little as 10 to 13 seconds. With the truck on the upper level, it is not nearly as efficient. The production performance ratio observed was relatively low, which indicates inadequate production per hour. It is recommended that high production rates can be obtained by giving proper training to the operator [27].

Proposed the model to automatically gather and analyze the monitoring data, which provides the construction manager with real-time control information. The model was designed for road construction. GPS (Global Positioning System) technology is used for automating data collection, showing the location of all the earthmoving and excavating equipment while working on the project [28] obtained the problems concerned with equipment usage and their output and how they harmfully affect the cost is realized. Major problems relating to equipment usage are found to be difficulty in management, scheduling, and maintenance of the machines, the laying of unwanted cost due to unseen factors, failure, and wrong choice of technology (machines and their combinations). To prevent such a problem applying queuing theory for equipment selection to minimize the degree of delays by reducing cycle time and idle time and thus reducing the total cost [29].

In order to improve productivity, it is essential to improve the performance of the manufacturing systems. The desired production output is achieved through high equipment availability, which is influenced by equipment reliability and maintainability [30].

CHAPTER 3

RESEARCH METHODOLOGY

This chapter describes the various methodologies that are used in the study. It includes the study design, the targets population, and sampling technique, sampling design, sources of data, data collection instrument, procedures of data collection, methods of data processing and data analysis and ethical considerations

3.1 Research Area

The study of this research is carried out in Addis Ababa, which is the capital city of Ethiopia. This research deals with the main factor affecting the productivity of earthwork equipment in Addis Ababa city road authority projects.

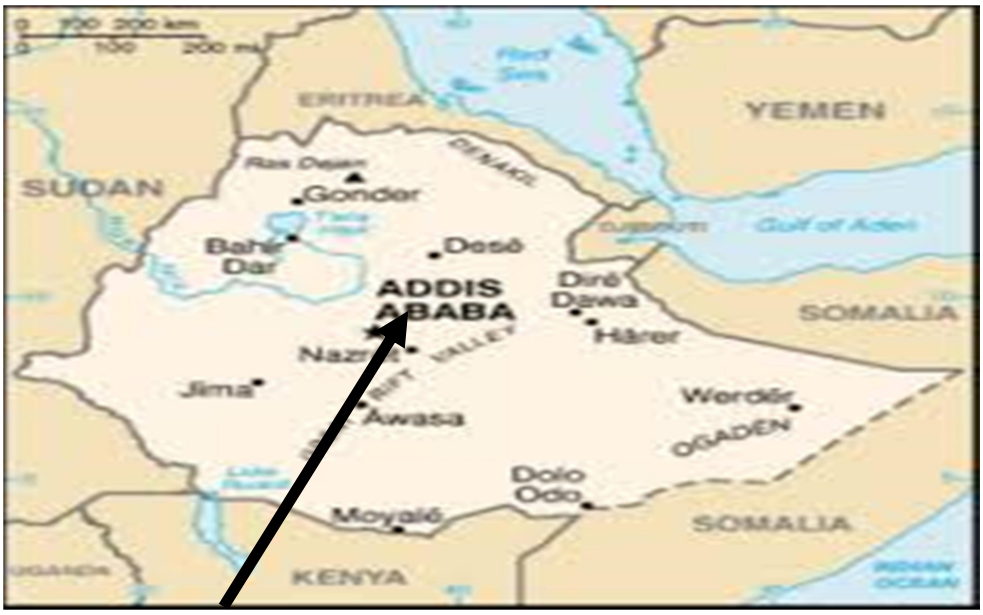

Figure -1: Map of Research Area (Source Google)

3.2 Research Design

The research focused on assessing the factors affecting the productivity of earthwork equipment. The questionnaires was prepared based on the literature and distributed to

concerning bodies. Recording of data from the questionnaire, analyzing and interpreting the collected data, then conclusion and recommendation followed.

Moreover, the actual output of equipment is collected to check the efficiency of equipment so that to reinforce the research.

In this study, the whole variables and factors that affect the productivity of earthwork equipment under different situations are identified in order of their effect.

3.3 Study Variables

Dependent and independent variables are identified and briefly discussed in the research.

Dependent variable:- Productivity of earthwork equipment

Independent variable:- From the literature review, the independent variables are identified and classified into five groups based on nature and characteristics they have.

- Environmental
- Management
- Operator
- Equipment
- Technical

The different variables under the above groups are discussed briefly for their effect in productivity of earthwork equipment in asphalt road projects

3.4 Study Population and Sampling Method

3.4.1 Study Population

The populations of the study are professionals, experts, and experienced people who are working in 13 asphalt road projects in Addis Ababa City. The research is conducted on asphalt road projects which are under construction with the supervision of Addis Ababa City Roads Authority. The research focused on borrow material production within the road projects. Two types of earthwork equipment (dozer and excavator) are used in the production of borrow material. Data through questionnaires are collected for different factors that affect earthwork equipment productivity. Project managers, construction engineers, professionals, and other experts and experienced people working on behalf of

the contractor and consultant have participated in the research through questionnaires and interviews.

3.4.2 Sampling Method

The type of sampling adapted for this research is purposive sampling. 18 road projects are available under the team-1 group. Among these projects, 16 are being constructed by a local company and two by the international company. Considering the nature of the project, the similarity among the management of the company, and the quality they have, the sampling is focused on the local contractors and the purposive sampling technique is used in the research. This sampling technique is selected as it uses the best knowledge concerning the sample project, better control of significant variables, and sample group data can easily be matched. Moreover, it is cost-effective.

Though the number of asphalt road projects under team-1 has been 16, three of the projects have been completed during the study period. As a result, the research is conducted on 13 of the remaining active projects being constructed by a local company.

Hence, the sample size is two types of earthwork equipment (dozer and excavator) found in 13 road projects in Addis Ababa City Roads Authority. Seven questionnaires for each project and a total of 91 questionnaires is distributed to the stakeholder in the projects. 87 questionnaire is collected from a total of 91.

3.5 Sources of Data

The source of data for the research is the literature review, books, journals, articles and seminar conferences, which focus on road projects mainly on the productivity of earthwork equipment. Moreover, technical reports concerning equipment which is found in the archive of the project, technical report of experts in the road project in the different hierarchy has been used as input for the research.

3.6 Data collection tools/Research Instrument

In this study, two types of data sources are used for investigating the factors that affect the productivity of earthwork equipment and to calculate the effectiveness of earthwork equipment. The primary data sources are questionnaires, actual observation, and measurement made on site. Literature review, books, journals, articles, technical report of experts and seminar conference which focus on road projects mainly on the productivity of earthwork equipment are used as secondary data sources.

The questionnaire survey is used as data collection tools for this study to get information about the factors that affect earthwork equipment productivity.

Moreover, field data is collected to check the efficiency of the equipment and to strengthen the assessment in identifying the factors that affect the productivity of the equipment.

3.7 Methods of Data Analysis and Evaluation

3.7.1 Methods of Efficiency Analysis and Evaluation

The research objectives were achieved through the analysis of the observed and measured field data to get the overall equipment effectiveness or efficiency. This means efficiency is a factor of the actual operational hour, idle hour, and down an hour of the equipment throughout the working time of the project. Four projects were randomly selected from the sixteen projects to check efficiency based on the actual availability of the equipment. Three days of data for each selected project are collected.

The equipment efficiency was computed by formula given below

$$EE = OP/WH*100$$

$$WH = OP+ID+DW$$

Given that

EE = Equipment Efficiency, OP = Operational Hour, ID = Idle Hour, DW = Down Hour

From the actual observation on the selected projects, the contributing factors were identified, and the percentages of the factor groups were compared.

3.7.2 Methods of Factors Affecting Earthwork Equipment Productivity Analysis and Evaluation

The second methodology used for this study is questionnaires. The questionnaires that contain factors for all targeted equipment were carefully designed from literature, internet, and materials around earthwork construction equipment. It was organized in the form of a priority scaling shown in Table-2.

Table-2 priority scale used for data measurement

Item	Extremely Significant	Very Significant	Moderately Significant	Slightly Significant	Not Significant
Scale	5	4	3	2	1

(5 = extremely significant, 4 = very significant, 3 = moderately significant, 2 = slightly significant and 1 = not significant).

There were 13 under-construction road projects under the team one in Addis Ababa City Roads Authority during the study; the three of them are completed at the time of the study. The questionnaires were distributed to professionals, and the related skilled workforce is engaged in Addis Ababa City Roads Authority Project. Moreover, the interview was done with experts and professionals in road projects.

The data collected was summarized and analyzed correctly and interpreted to give meaningful findings.

The relative importance index method (RII) is used to determine the most significant factors affecting the productivity of earthwork equipment in Addis Ababa city road authority projects. The relative importance index is computed as [18].

$$RII = \frac{5(n5) + 4(n4) + 3(n3) + 2(n2) + 1(n1)}{5(n1 + n2 + n3 + n4 + n5)} * 100$$

Where,

n5= number of respondents who has chosen the factor commitment as extremely Significant

n4= number of respondents who have chosen the factor commitment as very significant.

n3= number of respondents who have chosen the factor commitment as moderately significant.

n2= number of respondents who have chosen the factor commitment as slightly significant.

n1= number of respondents who have chosen the factor commitment as not significant.

Statistical test using SPSS software was made to check the correlation and the relativity of the data

3.7.2.1 Questionnaire approach

A questionnaire was developed to assess the perceptions of Project Managers, Site Engineers and Operators due to the importance index for the factor affecting the productivity of equipment engaged on earthwork activity in Addis Ababa city road authority projects. Factors affecting earthwork equipment productivity in all active road construction projects under team-1 group of Addis Ababa city road authority are identified and analyzed in the research.

3.7.2.2 Questionnaire design and content

The draft questionnaire was discussed with the supervisor of the thesis. The final questionnaire contains factors affecting earthwork equipment productivity for all targeted equipment. The respondents were asked to fill the questionnaire, and they had assured that the information was confidential and only for research purposes. The questionnaire included two parts; these parts are general organization information, factors affecting earthwork equipment productivity.

3.7.2.3 Questionnaire General Information

Six items were prepared for asking information about the organization such as the name of the Organization, Grade of the contractor, total project cost, his/her current position within the company, respondent's designation, and his/her experience. (The questionnaire is included in Appendix A). The results indicate a reasonably good spread of respondents in terms of the validity used for the study. Therefore, their views and opinions are deemed a reliable sample for the study.

3.7.3 Statical Test of data

3.7.3.1 Reliability statistics

This section presents test of reliability of questionnaire according to the study. The reliability of an instrument is the degree of consistency which measures the attribute; it is supposed to be measuring (Polit & Hunger, 1985 as cited melese,2016). The less variation an instrument produces in repeated measurements of an attribute, the higher its reliability.

Chronbach's coefficient alpha (George and Mallery, 2003 as cited melese,2016) is designed as a measure of internal consistency, that is, do all items within the instrument measure the same thing? Chronbach's alpha is used here to measure the reliability of the

questionnaire between each field. The normal range of Chronbach's coefficient alpha value between 0.0 and + 1.0. The closer the Alpha is to 1, the greater the internal consistency of items in the instrument being assumed. The formula that determines alpha is fairly simple and makes use of the items (variables), k, in the scale and the average of the inter-item correlations.

$$\alpha = \frac{k\bar{r}}{1 + (k-1)\bar{r}}$$

As the number of items (variables) in the scale (k) increases the value becomes large. Also, if the inter correlation between items is large, the corresponding will also be large. Since the alpha value is inflated by a large number of variables then there is no set interpretation as to what is an acceptable alpha value. A rule of thumb that applies to must situations is:

0.9 Up to 1.0 Excellent

0.8 Up to 0.9 Good

0.7 Up to 0.8 Acceptable

0.6 Up to 0.7 Questionable

0.5 Up to 0.6 Poor

0.0 Up to 0.5 Unacceptable

3.7.3.2 statical test for response of project

Reliability Statistics of response of projects and respondents for Dozer

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.928	.929	13

Reliability Statistics of response of projects and respondents for Excavator

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.902	.902	13

Reliability Statistics of response of projects and respondents for overall

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.930	.930	13

3.8 Summary of the factors affecting equipment productivity

After reviewing the literature, 33 variables are selected as the factors affecting earthwork production equipment productivity. Based on nature and characteristics, these factors are classified under five groups, namely Environmental factor, Equipment factor, Human factor, Technical factor, and Management factor, as listed below in the table.

Table -1: Summary of the factors affecting earthwork equipment in asphalt road project

A. Environmental Factor	**B. Management Factor**
1. Effect of temperature	1. Less contact between operator and supervisor
2. Availability of working space	2. Equipment repair and maintenance facilities
3. Nature of material source	3. Equipment allocation problem
4. Humidity effect	4. Lack of supervision
5. Heavy rain	5. Inadequate construction method
6. Site ground condition	6. Lack of proper maintenance
7. Obstacle on site	7. Incompetent foreman
8. Strong wind	8. Mobilization time
	9. Fuel shortage
	10. Lack of coordination
	11. Insufficient lighting
C. Operator Factor	**D. Equipment Factor**
1. Operator skill	1. Condition of equipment
2. Lack of experience	2. Equipment efficiency
3. Disloyalty	3. Frequent equipment breakdown
4. Age	4. Bucket size
5. Personal problem	5. Spares not available
6. Lack of training	
7. Operator delay	
E. Technical Factor	
1. Lack of required material	
2. Material class	

This study focuses on earthwork activities, particularly on borrow material production in AACRA road projects. From experience on-site and according to AACRA technical

specification, the standard types of equipment used for borrow material production are dozer and excavator.

The questionnaires are distributed to stockholders working on the AACRA project to identify the significant factors affecting the productivity of earthwork types of equipment. Base on the response, the major factors that affect equipment productivity are listed in order of their intensity beginning from the 1st ranked factor.

Moreover, actual data is collected to check the efficiency of the types of equipment. Three-day data is collected for dozer and excavator to check the effectiveness of the equipment. This is has reinforced the effect of different contributing factors on the effectiveness and productivity of the equipment.

3.9 Ethical consideration

Before the beginning of the study, a consent letter from JIT written to contractors in Addis Ababa City Road Authority projects.

The data collected is confidential and is used only for research purposes. Data collection follows a regular procedure, which means data collected from professionals having knowledge and experience on road construction. The research is entirely dependent on data collected from professionals and experienced employees of the project, such as project manager, construction engineer, site engineer, superintendent, earthwork Forman, and head office technical person. Moreover, additional data collected from construction professionals engaged on behalf of the consultant and client. The data collected honestly based on the willingness of organizations to give information.

The investigator takes appropriate measures to ensure the research will not cause any physical or psychological harm to research participants. As a general rule, the study does not raise any ethical concerns.

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter describes the findings on factors affecting the productivity of earthwork equipment on Addis Ababa City Roads Authority. The analysis focused on excavation and borrows production equipment, which is dozer and excavator. The assessment result consists of three main sections. The first part focuses on determining the factors affecting earthwork equipment productivity in Addis Ababa city road authority projects based on the collected questionnaires. The second part focuses on checking the efficiency of earthwork equipment based on the operational hours of the equipment against the working hour of the project. Actual data was collected from four projects to check the operational hours of the equipment. The third part assesses the effect of equipment efficiency on the progress of road projects by comparing the actual productivity and the expected productivity. The expected productivity was calculated based on the hourly equipment output set in the project multiplied by the project working hour.

4.1 Analysis of the findings

4.1.1 Results of Questionnaire

The questionnaires are designed to collect data concerning the significant factors affecting earthwork equipment productivity in road construction projects in Addis Ababa City Road Authority projects and analyzed in the following section.

4.1.2Response rate

A total of 87 questionnaires were received from 91 respondents , as shown in Table-3. A total of about 91 questionnaires were distributed to 13 selected asphalt road projects under Team-1 in Addis Ababa city road authority projects. Seven questionnaires for each project were distributed. The respondents were Project managers, Construction manager, Resident engineer, Site engineers, Office engineer and Site supervisor, Superintendents, Foreman, and Operators. The respondents have practical experience in road projects. Their ample experience on road project is a suitable indication to find out the perceptive

of the relative importance factors affecting earthwork equipment productivity in road construction projects.

Table -3 Response rate

Projects	Distributed Questionnaires	Collected Questionnaires	Rate of Return (%)
Project 1	7	7	100
Project 2	7	7	100
Project 3	7	7	100
Project 4	7	7	100
Project 5	7	7	100
Project 6	7	7	100
Project 7	7	7	100
Project 8	7	7	100
Project 9	7	7	100
Project 10	7	7	100
Project 11	7	6	86
Project 12	7	6	86
Project 13	7	5	71
Total	**91**	**87**	**95.60**

4.1.3 General Information

This part is mainly designed to provide general information about the respondents in terms of the position and experience of the contact person.

4.1.4 Grade of contractor

All of the construction companies that responded to the questionnaires are grade one general contractor. Moreover, the consultant company is grade one consultants. It is believed that companies have qualified personnel and sufficient equipment.

4.1.5 Typical Size of Projects

The contract amount of the projects undertaken by the respondents' companies in Addis Ababa City Roads Authority Projects is more than 300 million.

4.1.6. Composition of Respondent

The respondents are composed of the Project manager, Resident engineer (client's supervisor), and Construction managers, Engineer (Office engineer, Site engineer and Site Supervisor), Superintendents, Foreman and Operators. About 40.23% are managers at a different level and 44.83% are engineers. About 14.94% of the respondents are composed of others (foreman, superintendent, and Operators).

The respondents were professionals and experienced workers who have adequate knowledge of road projects. This shows that the questionnaires were filled by professionals who have ample experience in the road construction industry, thereby ensuring the credibility and reliability of the findings.

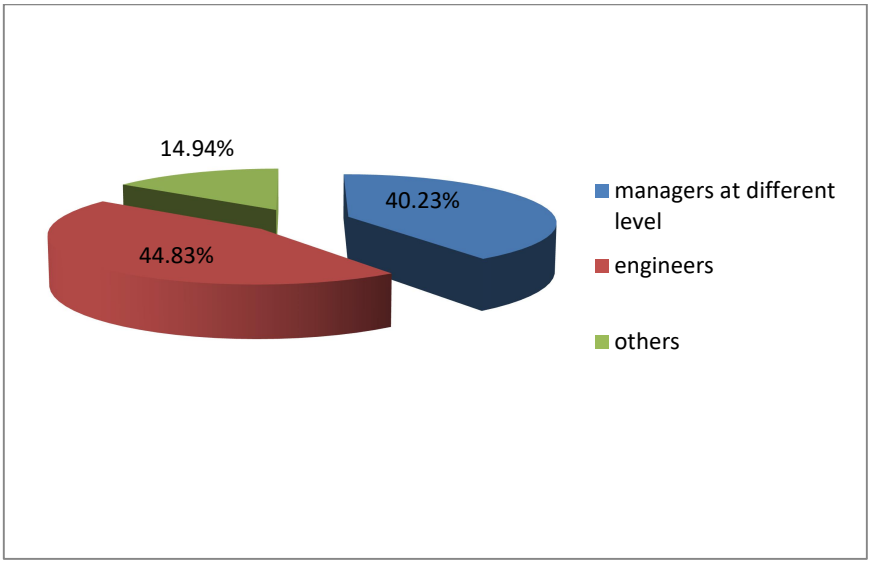

Figure-2 Type of respondent

4.1.7 Work Experience of the respondent

Table - 4 Experience of the respondent

Title	Experience in years				
	1 - 5 yrs	6 -10 yrs	11 -15 yrs	16-20yrs	>20yrs
Project Manager		2	3	4	3
Construction Manager		5	4	2	1
Resident Engineer			7	1	3
Site Supervisor		6	2	5	
Site Engineer	4	6	3		
Office Engineer	7	4	2		
Others (Superintendent, Foreman, and Operators)	1	4	5	2	1
Total	12	27	26	14	8

The Table-4 indicates that 13.79% of the respondents have experienced between 1 to 5years at road construction works and 31.03% of the respondents have experienced between 6 to 10 years, 29.89% of the respondents have between 11 to 15 years of experience in the road construction industry, while 16.09% have between 16 to 20 years and 9.20% have worked for more than 30 years in the road construction industry.

This indicates that the respondents have sufficient insight into the subject area being researched, and therefore proffer responses are well enough to warrant a satisfactory conclusion on the findings**.**

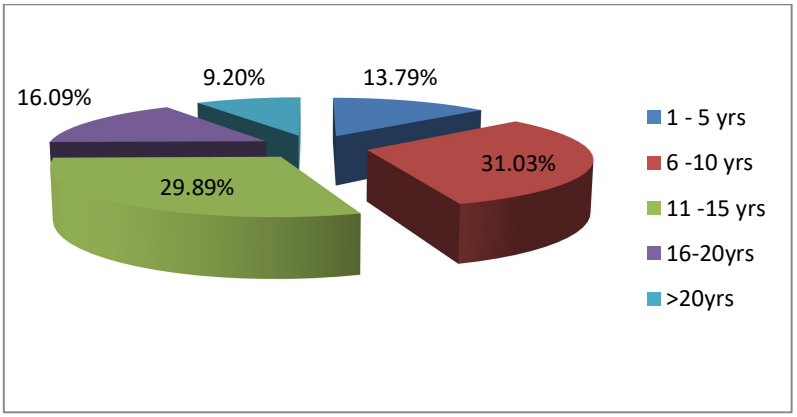

Figure -3 Experience of the respondent

4.1.8 Factors Affecting Earthwork Equipment Productivity in Road Projects for (Dozer)

The results of this study indicate the Relative Importance Index and Rank of factors Affecting Earthwork equipment Productivity particularly for dozer in Road Construction Projects in Addis Ababa City Roads Authority. Table 5 shows the summary ranking and Relative Importance Index of all factors.

Table-5 The relative importance index (RII) and rank of factors affecting productivity of earthwork equipment (Dozer) in road projects.

Factors	*Ordinal scale*					*Total*	*RII*	*Rank*
	5	*4*	*3*	*2*	*1*			
Environmental Factor								
1. Effect of temperature	15	64	72	50	19	220	0.506	33th
2. Availability of working space	45	108	72	36	9	270	0.621	21th
3. Nature of material source	105	84	63	24	12	288	0.662	13th
4. Humidity effect	5	40	51	66	26	188	0.432	37th
5. Heavy rain	135	80	48	36	6	305	0.701	7th
6. Site ground condition	30	124	105	18	6	283	0.651	16th
7. Obstacle on site	45	116	87	28	6	282	0.648	17th
8. Strong wind	20	52	51	52	27	202	0.464	36th
Management Factor								
1. Lack of communication between operator and supervisor	105	104	54	30	7	300	0.690	9th
2. Equipment repair and maintenance facilities	130	124	60	20	0	334	0.768	1st
3. Equipment allocation problem	45	84	84	46	6	265	0.609	24th
4. Lack of supervision	40	96	90	32	9	267	0.614	23th
5. Inadequate construction methodology	85	104	63	36	5	293	0.674	12th
6. Lack of proper maintenance	115	136	63	16	1	331	0.761	2nd
7. Incompetent foreman	110	104	57	32	4	307	0.706	6th
8. Mobilization time	30	72	75	54	11	242	0.556	27th
9. Fuel shortage	95	80	60	42	7	284	0.653	15th
10. Lack of coordination	45	112	72	42	5	276	0.634	19th
11. Insufficient lighting	25	84	72	34	20	235	0.540	29th
12. Night time work	40	52	63	56	17	228	0.524	32th
13. Expedited project schedule (over time, extra shifts, more crew)	20	60	69	50	20	219	0.503	34th
14. Work place preparation problem (request for inspection, supervision, approval to proceed)	35	84	54	48	17	238	0.547	28th

Operator Factor								
1.	Operator skill	145	76	33	38	9	301	0.692	8th
2.	Lack of experience	85	108	42	42	8	285	0.655	14th
3.	Disloyalty	10	76	96	32	18	232	0.533	30th
4.	Age	10	28	60	72	17	187	0.430	35th
5.	Personal problem	5	60	96	58	10	229	0.526	31th
6.	Lack of training	55	92	96	26	8	277	0.637	18th
7.	Operator delay	55	92	78	40	7	272	0.625	20th
8.	Level of motivation of the crew	130	104	39	34	5	312	0.717	5th
Equipment Factor								
1.	Condition of equipment	125	112	60	14	7	318	0.731	3rd
2.	Equipment efficiency	65	140	60	26	6	297	0.683	11th
3.	Frequent equipment breakdown	140	100	42	24	8	314	0.722	4th
4.	Bucket size	40	96	42	50	16	244	0.561	26th
5.	Spares not available	80	84	45	50	10	269	0.618	22th
Technical Factor								
1.	Lack of required material	100	108	48	38	5	299	0.687	10th
2.	Material class	40	84	72	40	14	250	0.575	25th

Based on Table 5, the top 5 most factors that affect earthwork equipment productivity are

- 1st Equipment repair and maintenance facilities, RII = 0.768
- 2nd Lack of proper maintenance RII=0.761
- 3rd Condition of equipment RII=0.731
- 4th Frequent equipment breakdown RII=0.722and
- 5th Level of the motivation of the crew RII=0.717

4.1.8.1Relative importance index and rank of group factors

Table -6 Relative importance index (RII) and rank of major groups affecting earthwork equipment productivity

Group of Factors	Total	RII	Rank
Environmental Factor	2038	0.586	5th
Management Factor	3819	0.627	3rd
Operator Factor	2111	0.607	4th
Equipment Factor	1442	0.663	1st
Technical Factor	549	0.631	2nd

As shown in Table 6, Equipment Factor has ranked 1st from 5 groups of factors with RII 0.663 which shows that Equipment Factor is the most dominant factor that affects Earthwork equipment productivity in road construction. Technical Factor rank 2nd place with RII of 0.631, Management Factor is in the 3rd place with RII of 0.627. Operator Factor is ranked 4th with RII of 0.607and the Environmental Factor is ranked 5th place with RII of 0.586.

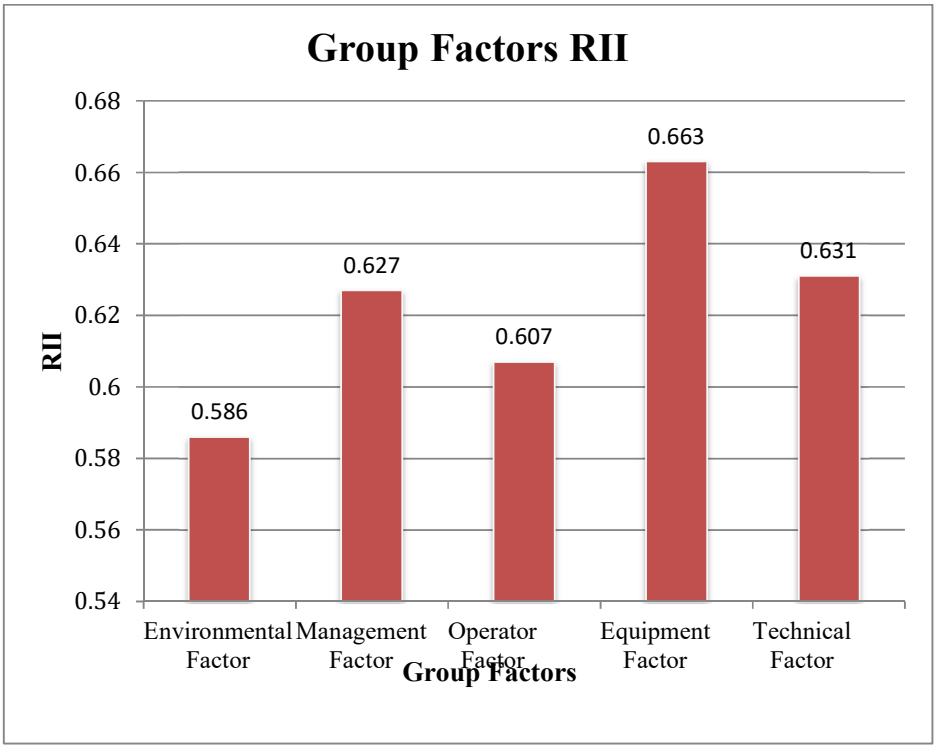

Figure-4 RII of the group of factors for dozer

4.1.8.2 Environmental Factor

Environmental Factor is one of the five group factors, which is ranked in the last place (5th) based on the RII value. The RII value is 0.586. Hence, this group factor affects the productivity of earthwork equipment less as compared to the other four group factors. Under Environmental Factor, 8 sub-factors are listed and each of them is ranked according to their RII value in their group and as a whole. The relative importance index (RII) and the rank of Environmental factors are summarized in Table 7 below.

Table-7 RII value and rank of Environmental factors for dozer

Environmental Factor	Total	RII	Overall Rank	Rank in group
1. Effect of temperature	220	0.506	33rd	6th
2. Availability of working space	270	0.621	21st	5th
3. Nature of material source	288	0.662	13th	2nd
4. Humidity effect	188	0.432	37th	8th
5. Heavy rain	305	0.701	7th	1st
6. Site ground condition	283	0.651	16th	3rd
7. Obstacle on site	282	0.648	17th	4th
8. Strong wind	202	0.464	36th	7th

The following graph shows the relative importance index (RII) and the rank of Environmental Factors

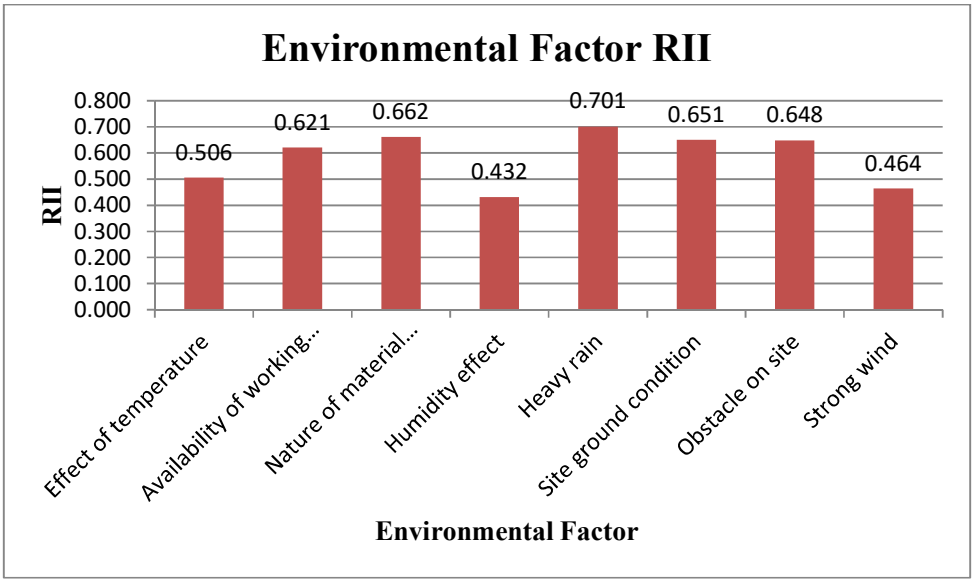

Figure-5 Relative importance index and rank of the environmental factor

From the Environmental Factor group, Heavy rain is ranked in the 1st place with RII of 0.701 and from the total factors, it is ranked in 7th place. This shows that the effect of heavy rain on the productivity of earthwork equipment particularly on the dozer, is high. The nature of the material source is among the most significant factor affecting equipment productivity and it is ranked in 2nd place from this group but ranked on 13th from overall factors. The site ground condition ranked 3rd from its group and ranked 16th from the total. Obstacle on-site ranked, Availability of working space, Effect of temperature 4th, 5th, and 6th from their group and 17th, 21th and 33th from overall

factors respectively. The factor ranked in the 7th place is Strong wind and it has ranked 36th from overall factors. Humidity effect ranked in the last (8^{th}) from their group and 37^{th} from the total factors.

4.1.8.3 Management factors

Management factors group has 14 sub-factors which are ranked according to their relative importance index (RII) value. The study identified the following factors that affect earthwork equipment productivity, equipment repair, and maintenance facilities which are ranked in 1^{st} with RII value of 0.768. It is ranked in 1^{st} place from the whole group too. This shows that the above factor affects equipment productivity seriously and to a high level. Lack of proper maintenance ranked in the 2^{nd} place from the group and the total factors too. Incompetent foreman is ranked in 3^{rd} place from the group and 6^{th} place from the total. Lack of communication between operator and supervisor is ranked in the 4^{th} place and 9^{th} from the total factor. Inadequate construction methodology is one of the management factors ranked in 5^{th} place. It is ranked in 12^{th} place from the total. The fuel shortage is ranked in 6^{th} place from the group and 15^{th} place from the total. Lack of coordination is ranked in 7^{th} place from the group and 19^{th} place from the total factors. Lack of supervision and equipment allocation problem is ranked in the place 8^{th} and 9^{th} from their group and 23^{rd} and 24^{th} from the total factors respectively. Mobilization time is ranked 10^{th} from the group and 27^{th} from the total. Workplace preparation problem (request for inspection, supervision, approval to proceed) and insufficient lighting are ranked in the place 11^{th} and 12^{th} from their group and 28^{th} and 29^{th} from the total factors respectively. Nighttime work is ranked in the place 13^{th} from the group and 32^{nd} from the total factors. Expedited project schedule (overtime, extra shifts, more crew) is ranked in the last from the group. It is ranked 14^{th} from the group and 34^{th} from the total factors.

The relative importance index (RII) value and the rank of the management factors are summarized in table-8.

Table- 8 Summary of relative importance index and rank of management factors

Management Factor	Total	RII	Overall Rank	Rank in group
Lack of communication between operator and supervisor	300	0.690	9th	4th
Equipment repair and maintenance facilities	334	0.768	1st	1th
Equipment allocation problem	265	0.609	24th	9th
Lack of supervision	267	0.614	23rd	8th
Inadequate construction methodology	293	0.674	12th	5th
Lack of proper maintenance	331	0.761	2nd	2nd
Incompetent foreman	307	0.706	6th	3rd
Mobilization time	242	0.556	27th	10th
Fuel shortage	284	0.653	15th	6th
Lack of coordination	276	0.634	19th	7th
Insufficient lighting	235	0.540	29th	12th
Night time work	228	0.524	32nd	13th
Expedited project schedule (overtime, extra shifts, more crew)	219	0.503	34th	14th
Workplace preparation problem (request for inspection, supervision, approval to proceed)	238	0.547	28th	11th

Figure 6 shows the graphical representation of the relative importance index (RII) and the rank of management factors.

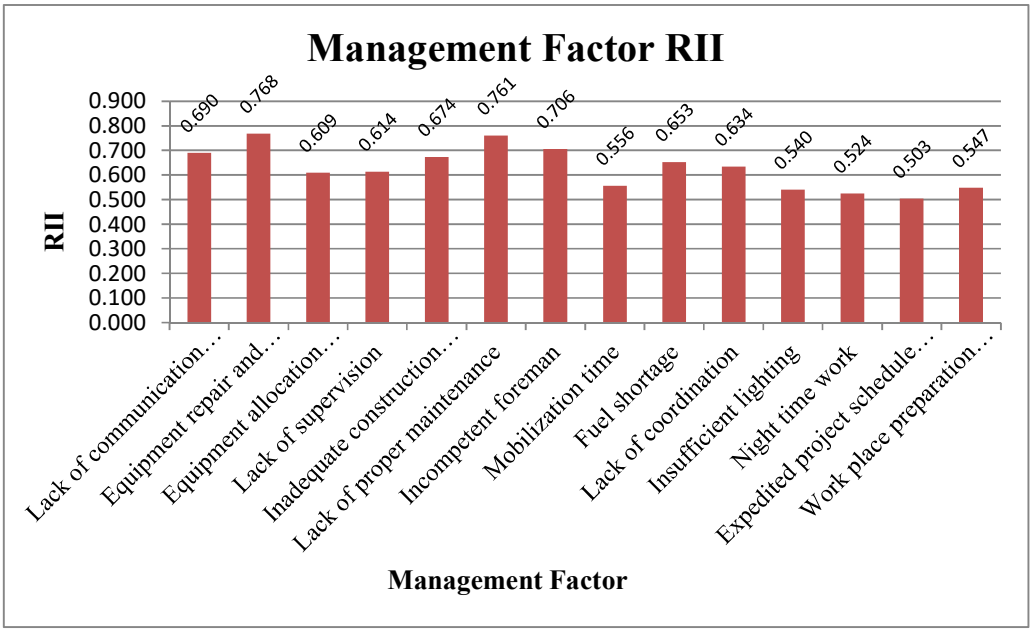

Figure-6 Relative Importance Index of management factor

4.1.8.4 Operator Factors

Operators have a direct connection to the productivity of the equipment. Unless the operator is qualified and motivated to work, the equipment has nothing to do with productivity. Operator factors are one of the five group factors identified in this research. It consists of eight sub-factors ranked based on their RII value. The level of the motivation of the crew is one of the sub-factors which is ranked in 1st place in the group with an RII value of 0.717. It is ranked in 5th place from the total factors. This shows that it is one of the significant 10 factors which affects earthwork equipment productivity. Hence, it is the responsibility of the contractor to identify the different motivators and use in his day to day operational works. Operator skill is ranked in 2nd place with RII value 0.692. It is ranked in 8th from the total which shows it is one of the significant 10factors in affecting earthwork equipment productivity. Lack of experience is ranked in 3rd place in the group and 14th place from the total. Lack of training is ranked in 4th place and 18th place from the group and total factors respectively. Operator delay is placed in the rank 5th from the group and 20th from the total factors. Disloyalty and personal problem is ranked in 6th and 7th place from the group and 30th and 31the from the total factor. Age is placed 8th rank from the group and 35th from the total

The relative importance index (RII) value and rank in group and an overall rank of motivation factors are summarized in Table-9

Table-9 summary of RII and rank of Operator factors for Dozer

Operator Factor	Total	RII	Overall Rank	Rank in group
Operator skill	301	0.692	8th	2nd
Lack of experience	285	0.655	14th	3rd
Disloyalty	232	0.533	30th	6th
Age	187	0.430	35th	8th
Personal problem	229	0.526	31th	7th
Lack of training	277	0.637	18th	4th
Operator delay	272	0.625	20th	5th
Level of the motivation of the crew	312	0.717	5th	1st

Figure 7 shows the relative importance index (RII) and the rank of factors under the group of Operator.

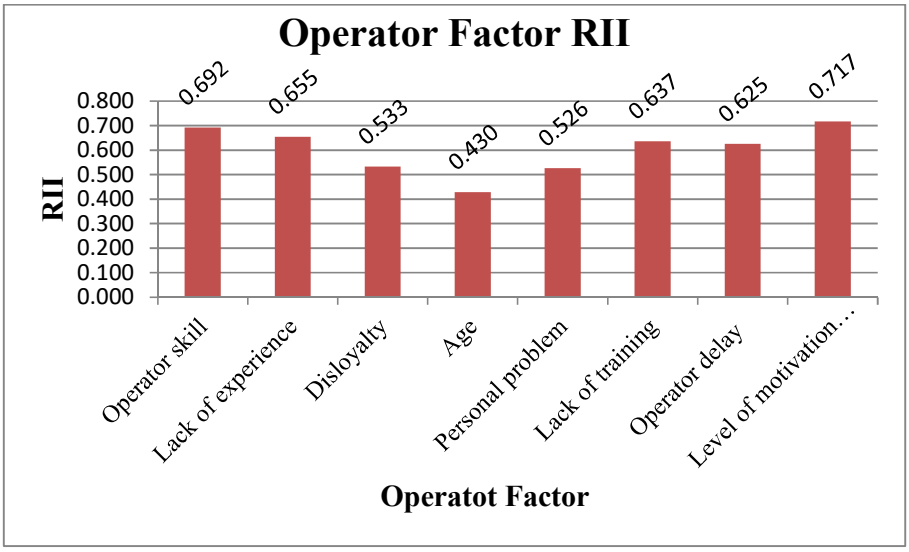

Figure-7 Relative importance index and rank of operator factor

4.1.8.5 Equipment Factors

Equipment factors are among the five group factors identified in affecting the productivity of earthwork equipment. It is ranked in the 1st place from the group factors which shows the high effect of the factor on earthwork equipment productivity. The group factor consists of five sub-factors which are; Condition of equipment, frequent equipment breakdown, Equipment efficiency, Spares not available, and Bucket size. The sub-factors are ranked according to their RII value and it is identified that the condition of the equipment is ranked in the 1st place with RII value of 0.731. From the total factors, it is ranked in 3rd place. This shows that the high effect of equipment conditions is affecting the productivity of earthwork equipment. Frequent equipment breakdown is ranked in the 2nd place from the group and 4th place from the total. The RII value is 0.722. Equipment efficiency is ranked in 3rd place from the group and 11th from the total. Spare not available is one of the sub-factor ranked in 4th place. It is placed on 22nd from the total. Bucket size is ranked in 5th and 26th from the group and the total respectively. The relative importance index (RII) value and rank in group and an overall rank of equipment factors are summarized in Table 10.

Table-10 summary of RII value and rank of Equipment Factors for Dozer

Equipment Factor	*Total*	*RII*	*Overall Rank*	*Rank in group*
Condition of equipment	318	0.731	3rd	1st
Equipment efficiency	297	0.683	11th	3rd
Frequent equipment breakdown	314	0.722	4th	2nd
Bucket size	244	0.561	26th	5th
Spares not available	269	0.618	22nd	4th

Figure 8 shows the relative importance index (RII) and the rank of Equipment Factors.

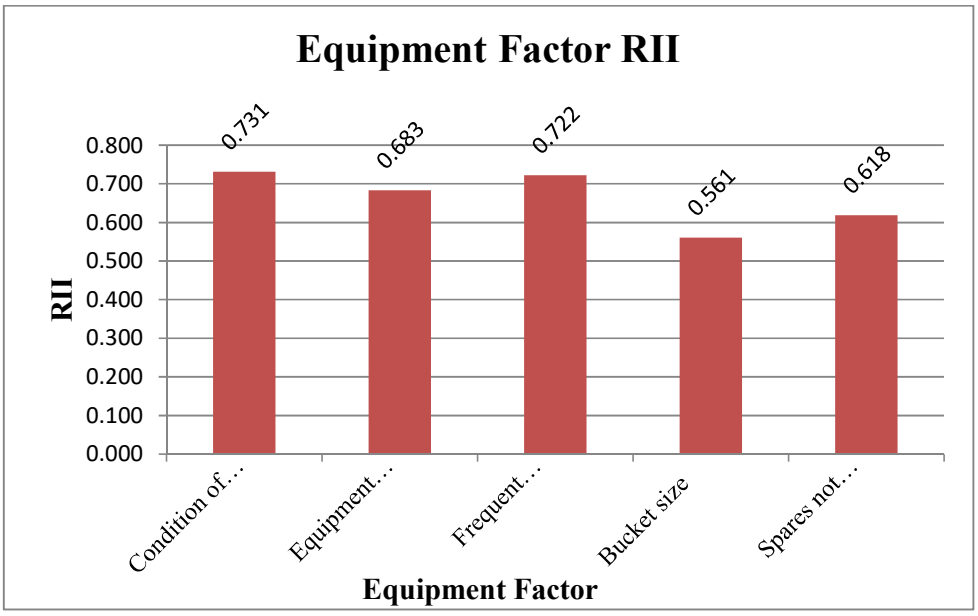

Figure-8 Relative Importance Index of Equipment factors

4.1.8.6 Technical Factor

The technical factor is one of the group factors which affects equipment productivity due to the requirement of the material as per the specification. It is ranked in the second place with RII value of 0.631. This shows that suitable material availability is one of the critical factors affecting equipment productivity. The group factor consists of two sub-factors which are lack of required material and material class. According to their RII value Lack of required material is ranked in the first place. This shows that equipment will be engaged in the removal of unnecessary material to get into the required material strata. This will result in high operational hours and lower productivity. Material class is ranked

in the second place. The productivity equipment will vary depending on the type of material being produced or executed. Depending on the material class, it might be soft or hard which will affect the productivity of the equipment. The RII value for the two factors is 0.687 and 0.575 respectively.

Table-11 summary of RII and rank of Technical factors for Dozer

Technical Factor	Total	RII	Overall Rank	Rank in group
Lack of required material	299	0.687	10th	1st
Material class	250	0.575	25th	2nd

Figure 9 shows the relative importance index and the rank of Technical factors

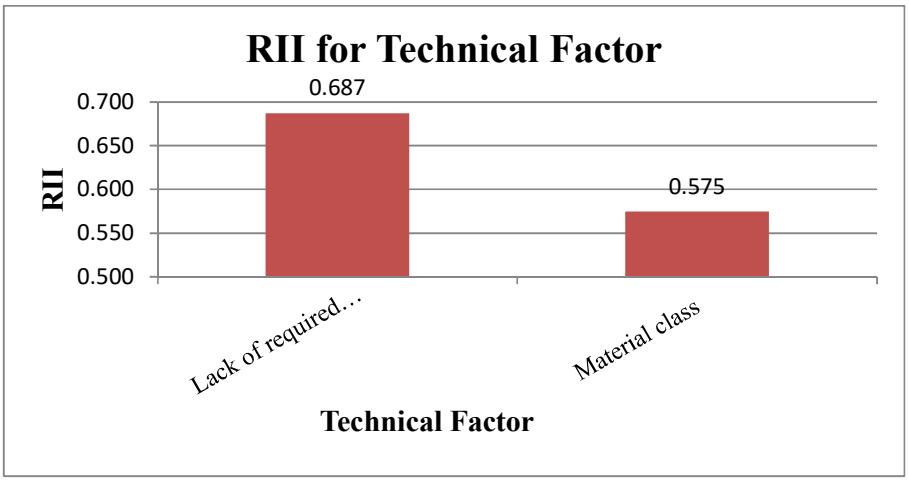

Figure-9 Relative importance index and rank of Technical factors

4.1.8.7 Overall Factors Affecting Earthwork Equipment Productivity According to RII Value

The following table shows the overall ranking of the 37 factors that affect Dozer productivity in road construction projects.

Table-12 Factors Affecting Earthwork Equipment (Dozer) Productivity

Factors	*Ordinal Scale*					*Total*	*RII*	*Rank*
	5	*4*	*3*	*2*	*1*			
Equipment repair and maintenance facilities	130	124	60	20	0	334	0.768	1st
Lack of proper maintenance	115	136	63	16	1	331	0.761	2nd
Condition of equipment	125	112	60	14	7	318	0.731	3rd
Frequent equipment breakdown	140	100	42	24	8	314	0.722	4th
Level of motivation of the crew	130	104	39	34	5	312	0.717	5th
Incompetent foreman	110	104	57	32	4	307	0.706	6th
Heavy rain	135	80	48	36	6	305	0.701	7th
Operator skill	145	76	33	38	9	301	0.692	8th
Lack of communication between operator and supervisor	105	104	54	30	7	300	0.690	9th
Lack of required material	100	108	48	38	5	299	0.687	10th
Equipment efficiency	65	140	60	26	6	297	0.683	11th
Inadequate construction methodology	85	104	63	36	5	293	0.674	12th
Nature of material source	105	84	63	24	12	288	0.662	13th
Lack of experience	85	108	42	42	8	285	0.655	14th
Fuel shortage	95	80	60	42	7	284	0.653	15th
Site ground condition	30	124	105	18	6	283	0.651	16th
Obstacle on site	45	116	87	28	6	282	0.648	17th
Lack of training	55	92	96	26	8	277	0.637	18th
Lack of coordination	45	112	72	42	5	276	0.634	19th
Operator delay	55	92	78	40	7	272	0.625	20th
Availability of working space	45	108	72	36	9	270	0.621	21st
Spares not available	80	84	45	50	10	269	0.618	22nd
Lack of supervision	40	96	90	32	9	267	0.614	23rd
Equipment allocation problem	45	84	84	46	6	265	0.609	24th
Material class	40	84	72	40	14	250	0.575	25th
Bucket size	40	96	42	50	16	244	0.561	26th
Mobilization time	30	72	75	54	11	242	0.556	27th
Work place preparation problem (request for inspection, supervision, approval to proceed)	35	84	54	48	17	238	0.547	28th
Insufficient lighting	25	84	72	34	20	235	0.540	29th
Disloyalty	10	76	96	32	18	232	0.533	30th
Personal problem	5	60	96	58	10	229	0.526	31th
Night time work	40	52	63	56	17	228	0.524	32nd
Effect of temperature	15	64	72	50	19	220	0.506	33rd
Expedited project schedule (over time, extra shifts, more crew)	20	60	69	50	20	219	0.503	34th
Age	10	36	66	74	17	203	0.467	35th
Strong wind	20	52	51	52	27	202	0.464	36th
Humidity effect	5	40	51	66	26	188	0.432	37th

Table 12 shows that the relative importance index (RII) value and rank of all factors merged from the group factors. According to the above table, the top 10 factors that affect dozer productivity includes Equipment repair and maintenance facilities, Lack of proper maintenance, Condition of equipment, Frequent equipment breakdown, Level of motivation of the crew, Incompetent foreman, Heavy rain, Operator skill, Lack of communication between operator and supervisor, Lack of required material respectively.

To avoid the problem of earthwork equipment productivity and to enhance their productivity, the contractor has to focus on the above significant factors identified.

Providing proper solutions for the above primary factors will help the contractor to avoid unnecessary idle hours of equipment. This will result in achieving the expected productivity as per the work schedule. Moreover, unnecessary costs due to low productivity will be avoided.

Hence, the contractor has to concentrate on the above-identified factors to avoid low productivity of earthwork equipment and for the smooth accomplishment of the project as per the schedule and with the intended budget.

Figure 10 shows the Relative Importance Index (RII) and the overall Rank of 37 factors.

4.1.9 Factors Affecting Earthwork Equipment Productivity in Road Projects for (Excavator)

The results of this study indicate the Relative Importance Index and Rank of factors Affecting Earthwork equipment Productivity, particularly for excavator in Road Construction Projects in Addis Ababa City Roads Authority. Table 13 below shows the summary ranking and Relative Importance Index of all factors.

Table-13 The relative importance index (RII) and rank of factors affecting productivity of earthwork equipment (Excavator) in road projects.

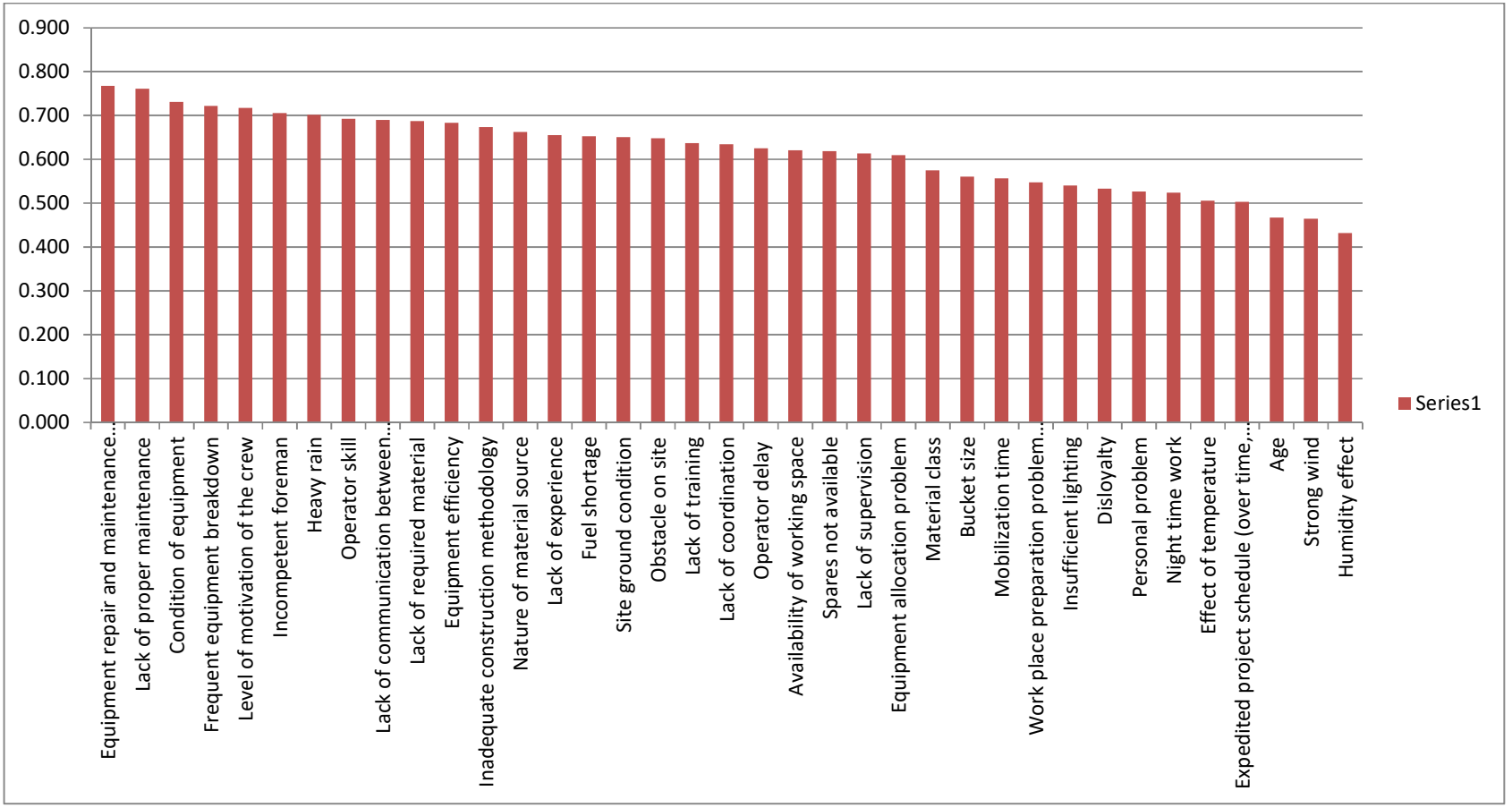

Figure-10 Overall Relative Importance Index and rank of all factors for Dozer

Table-13 the relative importance index (RII) and rank of factors Earthwork Equipment (Excavator) Productivity

Factors	Ordinal scale					Total	RII	Rank
	5	4	3	2	1			
Environmental Factor								
1. Effect of temperature	20	68	63	56	17	224	0.515	32nd
2. Availability of working space	40	100	48	58	9	255	0.586	25th
3. Nature of material source	100	72	72	28	11	283	0.651	13th
4. Humidity effect	20	44	63	54	24	205	0.471	35th
5. Heavy rain	110	60	42	62	5	279	0.641	17th
6. Site ground condition	15	104	108	32	6	265	0.609	21th
7. Obstacle on site	35	84	84	52	5	260	0.598	23rd
8. Strong wind	5	48	57	56	27	193	0.444	37th
Management Factor								
1. Lack of communication between operator and supervisor	105	100	45	38	7	295	0.678	8th
2. Equipment repair and maintenance facilities	120	108	72	24	0	324	0.745	1st
3. Equipment allocation problem	20	100	96	40	6	262	0.602	22nd
4. Lack of supervision	60	100	93	26	6	285	0.655	12th
5. Inadequate construction methodology	90	56	105	36	2	289	0.664	11th
6. Lack of proper maintenance	145	80	45	28	9	307	0.706	6th
7. Incompetent foreman	120	60	45	44	11	280	0.644	16th
8. Mobilization time	45	60	69	48	16	238	0.547	28th
9. Fuel shortage	65	108	48	50	6	277	0.637	19th
10. Lack of coordination	70	112	66	38	4	290	0.667	10th
11. Insufficient lighting	25	44	84	50	18	221	0.508	34th
12. Night time work	10	52	87	62	12	223	0.513	33rd
13. Expedited project schedule (over time, extra shifts, more crew)	30	80	51	40	24	225	0.517	31st
14. Workplace preparation problem (request for inspection, supervision, approval to proceed)	50	72	51	54	15	242	0.556	26th
Operator Factor								
1. Operator skill	145	88	45	30	6	314	0.722	3rd
2. Lack of experience	80	104	30	46	12	272	0.625	20th
3. Disloyalty	40	56	99	26	19	240	0.552	27th
4. Age	15	12	78	84	13	202	0.464	36th
5. Personal problem	15	52	102	56	9	234	0.538	29th
6. Lack of training	40	104	60	44	11	259	0.595	24th
7. Operator delay	55	96	78	46	3	278	0.639	18th
8. Level of motivation of the crew	130	96	42	38	4	310	0.713	4th

Equipment Factor								
1. Condition of equipment	95	152	36	14	11	308	0.708	5th
2. Equipment efficiency	65	144	48	26	9	292	0.671	9th
3. Frequent equipment breakdown	175	72	45	20	9	321	0.738	2nd
4. Bucket size	45	76	27	70	15	233	0.536	30th
5. Spares not available	105	72	36	64	4	281	0.646	15th
Technical Factor								
1. Lack of required material	100	116	39	38	6	299	0.687	7th
2. Material class	75	96	75	26	10	282	0.648	14th

Based on Table 13, the top five factors that profoundly affect earthwork equipment productivity are

- 1st Equipment repair and maintenance facilities, RII= 0.745
- 2nd Frequent equipment breakdown, RII=0.738
- 3rd Operator skill, RII=0.722
- 4th Level of the motivation of the crew, RII=0.713
- 5th Condition of equipment, RII= 0.708

4.1.9.1 Relative importance index and rank of group factors

Table -14 Relative importance index (RII) and rank of major groups affecting earthwork equipment productivity

Group of Factors (Excavator)	**Total**	**RII**	**Rank**
Environmental Factor	1964	0.564	5th
Management Factor	3758	0.617	3rd
Operator Factor	2109	0.606	4th
Equipment Factor	1435	0.659	2nd
Technical Factor	581	0.667	1st

As shown in Table 14, Technical Factor has ranked 1st from 5 groups of factors with RII 0.667 which shows that Technical Factor is the most dominant factor that affects earthwork equipment productivity in road construction. Equipment Factor rank 2nd place with RII of 0.659, Management Factor is in the 3rd place with RII of 0.617. Operator Factor is rank 4th with RII of 0.606 and Environmental Factor are ranked on the 5th place with RII of 0.564

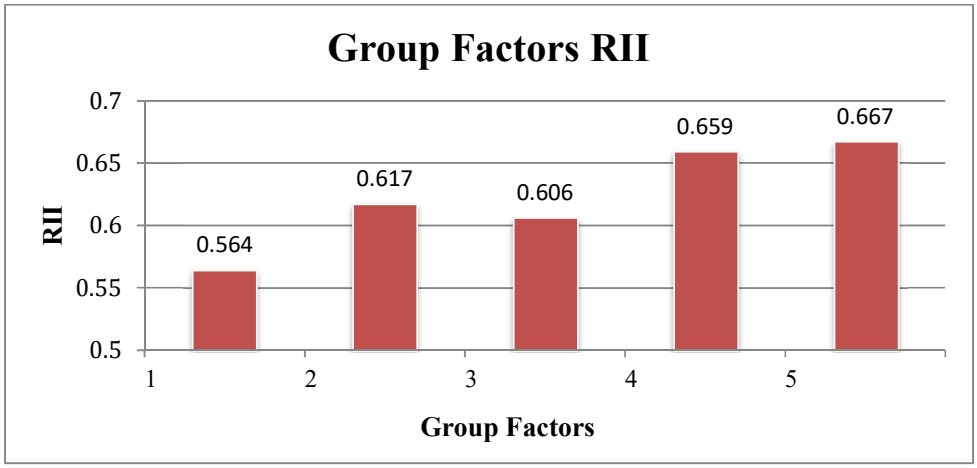

Figure-11 Rank and RII of the group of factors affecting Earthwork Equipment (Excavator) productivity

4.1.9.2 Environmental Factor

Environmental Factor is one of the five group factors which is ranked in the last (5^{th}) based on the RII value. The RII value is 0.564. Hence, this group factor affects the productivity of earthwork equipment less as compared to the other four group factors. Under Environmental Factor, 8 sub-factors are listed and each of them is ranked according to their RII value in their group and as a whole. The relative importance index (RII) and the rank of Environmental factors are summarized in Table-15 below.

Table-15 RII and rank of Environmental factors for excavator

Environmental Factor	Total	RII	Overall Rank	Rank in group
Effect of temperature	224	0.515	32^{nd}	6^{th}
Availability of working space	255	0.586	25^{th}	5^{th}
Nature of material source	283	0.651	13^{th}	1^{st}
Humidity effect	205	0.471	35^{th}	7^{th}
Heavy rain	279	0.641	17^{th}	2^{nd}
Site ground condition	265	0.609	21^{st}	3^{rd}
Obstacle on site	260	0.598	23^{rd}	4^{th}
Strong wind	193	0.444	37^{th}	8^{th}

Figure 12 shows the relative importance index (RII) and the rank of Environmental Factors.

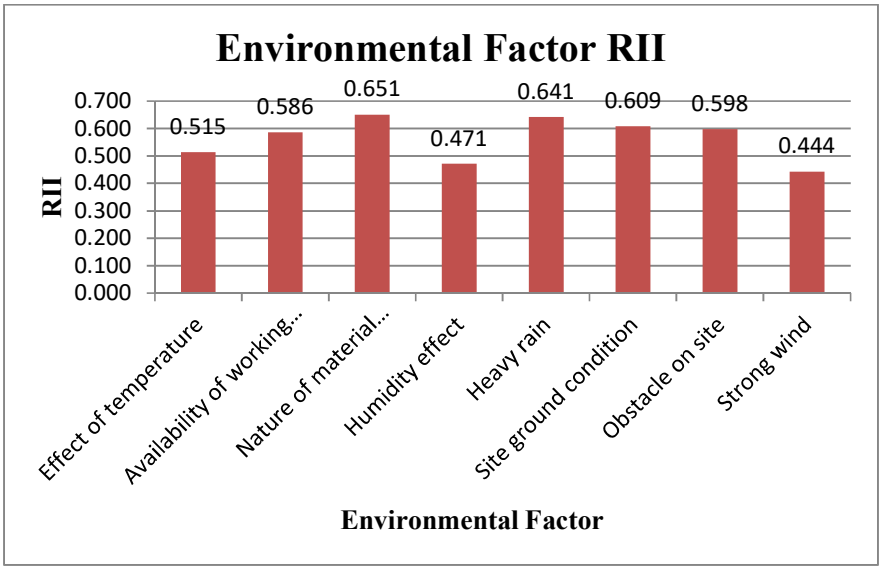

Figure-12 Relative importance index and rank of the environmental factor

From the Environmental Factor group, the Nature of material source is ranked in the 1st place with RII of 0.651 and from the total factors, it is ranked in the 13th place. This shows that the effect of the Nature of material source on the productivity of earthwork equipment particularly on the excavator, is high. Heavy rain is among the most significant factor affecting equipment productivity and it is ranked in 2nd place from this group but ranked on 17th from overall factors. The site ground condition ranked 3rd from its group and ranked 21th from the total. Obstacle on-site ranked, Availability of working space, Effect of temperature 4th, 5th, and 6th from their group and 23rd, 25th and 32th from overall factors respectively. The factor ranked in the 7th place is Humidity effect and it has ranked 35th from overall factors. Strong wind effect ranked in the last (8th) from their group and 37th from the total factors.

4.1.9.3 Management factors

Management factors group has 14 sub-factors which are ranked according to their relative importance index (RII) value. The study identified the following factors that affect earthwork equipment productivity, Equipment repair, and maintenance facilities which are ranked in 1st with RII value of 0.745. It is ranked in 1st place from the entire group too. This shows that the above factor affects equipment productivity seriously and to a high level. Lack of proper maintenance ranked in the 2nd place from the group and 6th place from the total factors. Lack of communication between operator and supervisor is

ranked in 3rd place from the group and 8th place from the total. Lack of coordination is ranked in the 4th place and 10th from the total factor. Inadequate construction methodology is one of the management factors ranked in 5th place. It is ranked in 11th place from the total. Lack of supervision is ranked in 6th place from the group and 12th place from the total. Incompetent foreman is ranked in 7th place from the group and 16th place from the total factors. Fuel shortage and Equipment allocation problem are ranked in the place 8th and 9th from their group and19th and 22nd from the total factors respectively. Workplace preparation problem (request for inspection, supervision, approval to proceed)is ranked 10th from the group and 26th from the total. Mobilization time and Expedited project schedule (overtime, extra shifts, more crew)are ranked in the place 11th and 12th from their group and 28th and 31st from the total factors respectively. Nighttime work is ranked in the place 13th from the group and 33rd from the total factors. Insufficient lighting is ranked in the last from the group. It is ranked 14th from the group and 34th from the total factors.

The relative importance index (RII) value and the rank of the management factors are summarized in table-16.

Table-16 Summary of relative importance index and rank of management factors for Excavator

Management Factor (Excavator)	Total	RII	Overall Rank	Rank in group
Lack of communication between operator and supervisor	295	0.678	8th	3rd
Equipment repair and maintenance facilities	324	0.745	1st	1st
Equipment allocation problem	262	0.602	22th	9th
Lack of supervision	285	0.655	12th	6th
Inadequate construction methodology	289	0.664	11th	5th
Lack of proper maintenance	307	0.706	6th	2nd
Incompetent foreman	280	0.644	16th	7th
Mobilization time	238	0.547	28th	11th
Fuel shortage	277	0.637	19th	8th
Lack of coordination	290	0.667	10th	4th
Insufficient lighting	221	0.508	34th	14th
Night time work	223	0.513	33rd	13th
Expedited project schedule (overtime, extra shifts, more crew)	225	0.517	31st	12th
Workplace preparation problem (request for inspection, supervision, approval to proceed)	242	0.556	26th	10th

Figure 13 shows the graphical representation of the relative importance index (RII) and the rank of management factors.

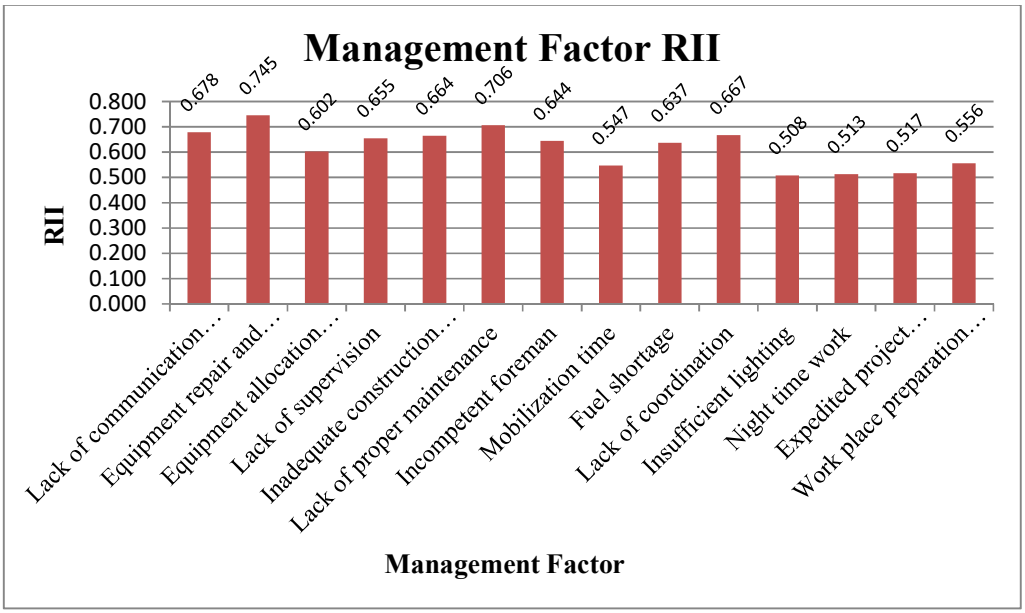

Figure-13 Relative Importance Index of management factor

4.1.9.4 Operator Factors

Operators have a direct connection to the productivity of the equipment. Unless the operator is qualified and motivated to work, the equipment has nothing to do with productivity. Operator factors are one of the five group factors identified in this research. It consists of eight sub-factors ranked based on their RII value. Operator skill is one of the sub-factors which is ranked in 1st place in the group with an RII value of 0.722. It is ranked in 3rd place from the total factors. This shows that it is one significant 10factors which affects earthwork equipment productivity. The level of the motivation of the crew is ranked in 2nd place with RII value 0.713. It is ranked in 4th from the total; hence, it is the responsibility of the contractor to identify the different motivators and use in day to day operational works. Operator delay is ranked in 3rd place in the group and 18th place from the total. Lack of experience is ranked in 4th place and 20th place from the group and total factors respectively. Lack of training is placed in the rank 5th from the group and 24th from the total factors. Disloyalty and Personal problem is ranked in 6th and 7th place from

the group and 27th and 29the from the total factor. Age is placed 8th rank from the group and 36th from the total

The relative importance index (RII) value and rank in group and an overall rank of motivation factors are summarized in Table 17.

Table-17 summary of RII and rank of Operator factors for Excavator

Operator Factor (Excavator)	Total	RII	Overall Rank	Rank in group
Operator skill	314	0.722	3rd	1st
Lack of experience	272	0.625	20th	4th
Disloyalty	240	0.552	27th	6th
Age	202	0.464	36th	8th
Personal problem	234	0.538	29th	7th
Lack of training	259	0.595	24th	5th
Operator delay	278	0.639	18th	3rd
Level of the motivation of the crew	310	0.713	4th	2nd

The following graph shows the relative importance index (RII) and the rank of factors under the group of Operator.

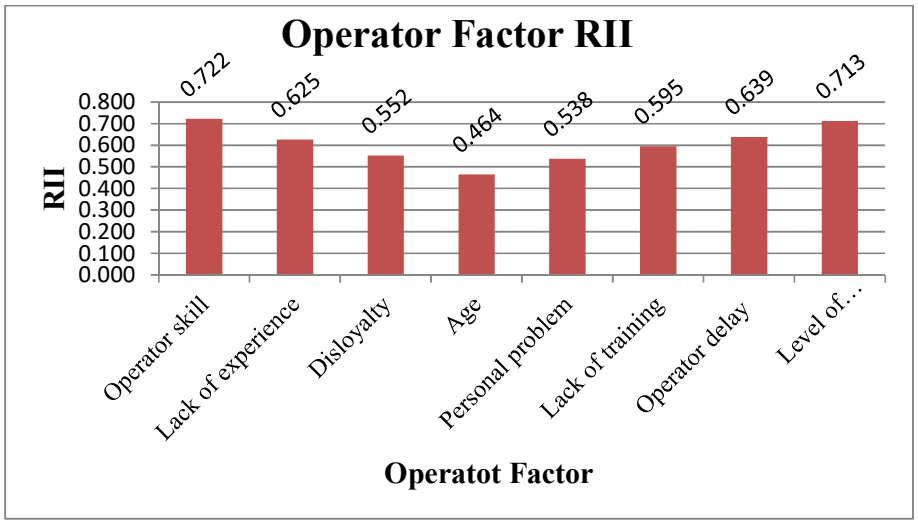

Figure-14 Relative importance index and rank of operator factor

4.1.9.5 Equipment Factors

Equipment factors are among the five group factors identified in affecting the productivity of earthwork equipment. It is ranked in the 2nd place from the group factors which shows the high effect of the factor on earthwork equipment productivity. The group consists of five sub-factors which are; Condition of equipment, frequent equipment breakdown, Equipment efficiency, Spares not available and Bucket size. The sub-factors are ranked according to their RII value and frequent equipment breakdown is ranked in the 1st place with RII value of 0.738. From the total factors, it is ranked in 2nd place. This shows the high effect of frequent equipment breakdown in affecting the productivity of earthwork equipment. The condition of the equipment is ranked in 2nd place from the group and 5th place from the total. The RII value is 0.708. Equipment efficiency is ranked in 3rd place from the group and 9th from the total. Spare not available is one of the sub-factor ranked in 4th place. It is placed on 15th from the total. Bucket size is ranked in 5th and 30th from the group and the total respectively. The relative importance index (RII) value and rank in group and an overall rank of equipment factors are summarized in Table 18.

Table-18 summary of RII and rank of Equipment Factors for Excavator

Equipment Factor	Total	RII	Overall Rank	Rank in group
Condition of equipment	308	0.708	5th	2nd
Equipment efficiency	292	0.671	9th	3rd
Frequent equipment breakdown	321	0.738	2nd	1st
Bucket size	233	0.536	30th	5th
Spares not available	281	0.646	15th	4th

Figure 15 shows the relative importance index (RII) and the rank of Equipment Factors.

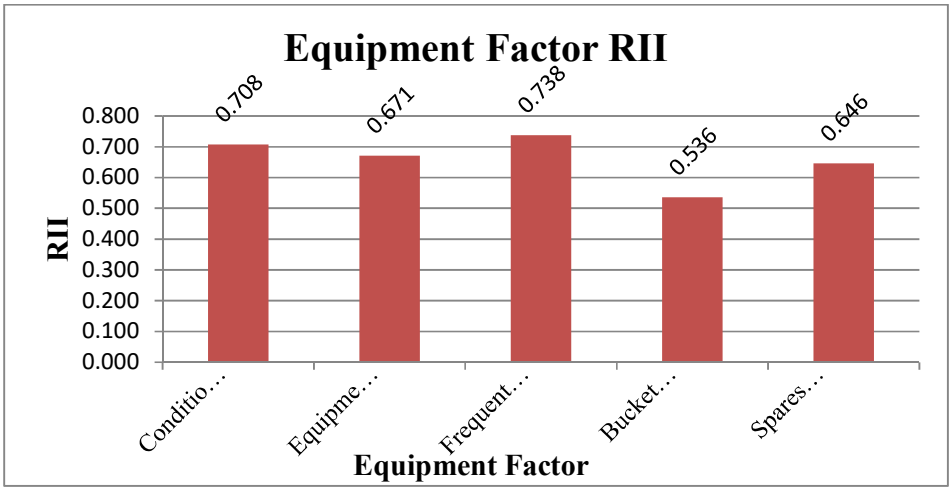

Figure-15 Relative Importance Index of Equipment factors

4.1.9.6 Technical Factor

The technical factor is one of the group factors which affects equipment productivity due to the requirement of the material as per the specification. It is ranked in the first place with RII value of 0.667. This shows that suitable material availability is one of the critical factors affecting equipment productivity. The group factor consists of two sub-factors which are lack of required material and material class. According to their RII value Lack of required material is ranked in the first place. This shows that equipment will be engaged in the removal of unnecessary material to get into the required material strata. This will result in high operational hours and lower productivity. Material class is ranked in the second place. The productivity equipment will vary depending on the type of material being produced or executed. Depending on the material class, it might be soft or hard which will affect the productivity of the equipment. The RII value for the two factors is 0.687 and 0.648 respectively

Table-19 summary of RII and rank of Technical factors for Excavator

Technical Factor (Excavator)	**Total**	**RII**	**Overall Rank**	**Rank in group**
Lack of required material	299	0.687	7^{th}	1^{st}
Material class	282	0.648	14^{th}	2^{nd}

Figure 16 shows the Relative importance index and rank of Technical factors

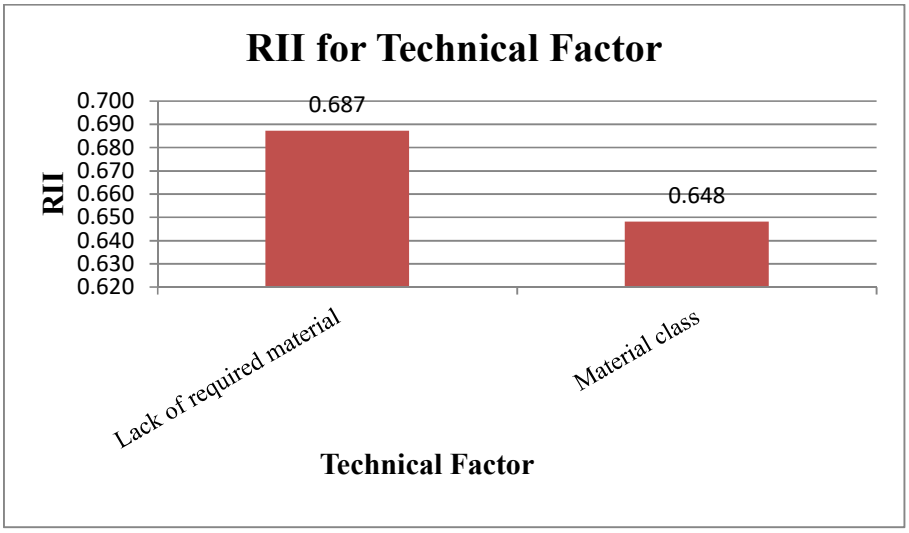

Figure-16 Relative importance index and rank of Technical factors

4.1.9.7 Overall Factors Affecting Earthwork Equipment (Excavator) Productivity According to RII Value

The following table shows the overall ranking of 37 factors that affect Excavator productivity in road construction projects.

Table-20 Overall ranking and RII value of Factors Affecting Earthwork Equipment (Excavator) Productivity

Factors	*Ordinal Scale*					*Total*	*RII*	*Rank*
	5	*4*	*3*	*2*	*1*			
Equipment repair and maintenance facilities	120	108	72	24	0	324	0.745	1st
Frequent equipment breakdown	175	72	45	20	9	321	0.738	2nd
Operator skill	145	88	45	30	6	314	0.722	3rd
Level of motivation of the crew	130	96	42	38	4	310	0.713	4th
Condition of equipment	95	152	36	14	11	308	0.708	5th
Lack of proper maintenance	145	80	45	28	9	307	0.706	6th
Lack of required material	100	116	39	38	6	299	0.687	7th
Lack of communication between operator and supervisor	105	100	45	38	7	295	0.678	8th
Equipment efficiency	65	144	48	26	9	292	0.671	9th

Lack of coordination	70	112	66	38	4	290	0.667	10th
Inadequate construction methodology	90	56	105	36	2	289	0.664	11th
Lack of supervision	60	100	93	26	6	285	0.655	12th
Nature of material source	100	72	72	28	11	283	0.651	13th
Material class	75	96	75	26	10	282	0.648	14th
Spares not available	105	72	36	64	4	281	0.646	15th
Incompetent foreman	120	60	45	44	11	280	0.644	16th
Heavy rain	110	60	42	62	5	279	0.641	17th
Operator delay	55	96	78	46	3	278	0.639	18th
Fuel shortage	65	108	48	50	6	277	0.637	19th
Lack of experience	80	104	30	46	12	272	0.625	20th
Site ground condition	15	104	108	32	6	265	0.609	21st
Equipment allocation problem	20	100	96	40	6	262	0.602	22nd
Obstacle on site	35	84	84	52	5	260	0.598	23rd
Lack of training	40	104	60	44	11	259	0.595	24th
Availability of working space	40	100	48	58	9	255	0.586	25th
Work place preparation problem (request for inspection, supervision, approval to proceed)	50	72	51	54	15	242	0.556	26th
Disloyalty	40	56	99	26	19	240	0.552	27th
Mobilization time	45	60	69	48	16	238	0.547	28th
Personal problem	15	52	102	56	9	234	0.538	29th
Bucket size	45	76	27	70	15	233	0.536	30th
Expedited project schedule (over time, extra shifts, more crew)	30	80	51	40	24	225	0.517	31st
Effect of temperature	20	68	63	56	17	224	0.515	32nd
Night time work	10	52	87	62	12	223	0.513	33rd
Insufficient lighting	25	44	84	50	18	221	0.508	34th
Humidity effect	20	44	63	54	24	205	0.471	35th
Age	15	12	78	84	13	202	0.464	36th
Strong wind	5	48	57	56	27	193	0.444	37th

Table 20 shows that the relative importance index (RII) value and rank of all factors merged from the group factors. According to the above table, the top 10 factors that affect

excavator productivity includes Equipment repair and maintenance facilities, Frequent equipment breakdown, Operator skill, Level of motivation of the crew, Condition of equipment, Lack of proper maintenance, Lack of required material, Lack of communication between operator and supervisor, Equipment efficiency, Lack of coordination respectively.

To avoid the problem of earthwork equipment productivity and to enhance their productivity, the contractor has to focus on the above significant factors identified.

Providing proper solutions for the above primary factors will help the contractor to avoid unnecessary idle hours of equipment. This will result in achieving the expected productivity as per the work schedule. Moreover, unnecessary costs due to low productivity will be avoided.

Hence, the contractor has to concentrate on the above-identified factors to avoid low productivity of earthwork equipment and for the smooth accomplishment of the project as per the schedule and with the intended budget.

Figure 17 shows the Relative Importance Index (RII) and the overall Rank of 37 factors.

4.2 Degree of agreement between projects

The projects which were evaluated, values of Chronbach's Alpha were in the range from 0.9 and 1. This range is considered excellent; since the result ensures reliability of response of each project. Chronbach's Alpha equals (0.928 for dozer and0.902 for excavator) for the entire projects which indicate an excellent reliability of the entire response data.

The projects which were evaluated, values of Chronbach's Alpha were in the range from 0.9 and 1. This range is considered excellent; since the result ensures reliability of response of each project. Chronbach's Alpha equals o.930 for the entire projects which indicate an excellent reliability of the entire response data. One of the more common measures used is the Pearson correlation, which estimates a relationship between two interval variables. The correlations between the projects are measured by Pearson Correlation, and some have excellent correlation between projects. Most correlation between the projects fall within the good range, while few are falling in an acceptable range.

4.3 Efficiency (Utilization factor) analysis of earthwork Equipment

The efficiency (utilization factor) of earthwork equipment like Dozer and Excavator, was assessed based on the recording of actual operational hour working at the borrow sit for the proper equipment for each selected four road projects involved under Addis Ababa city road authority projects was calculated.

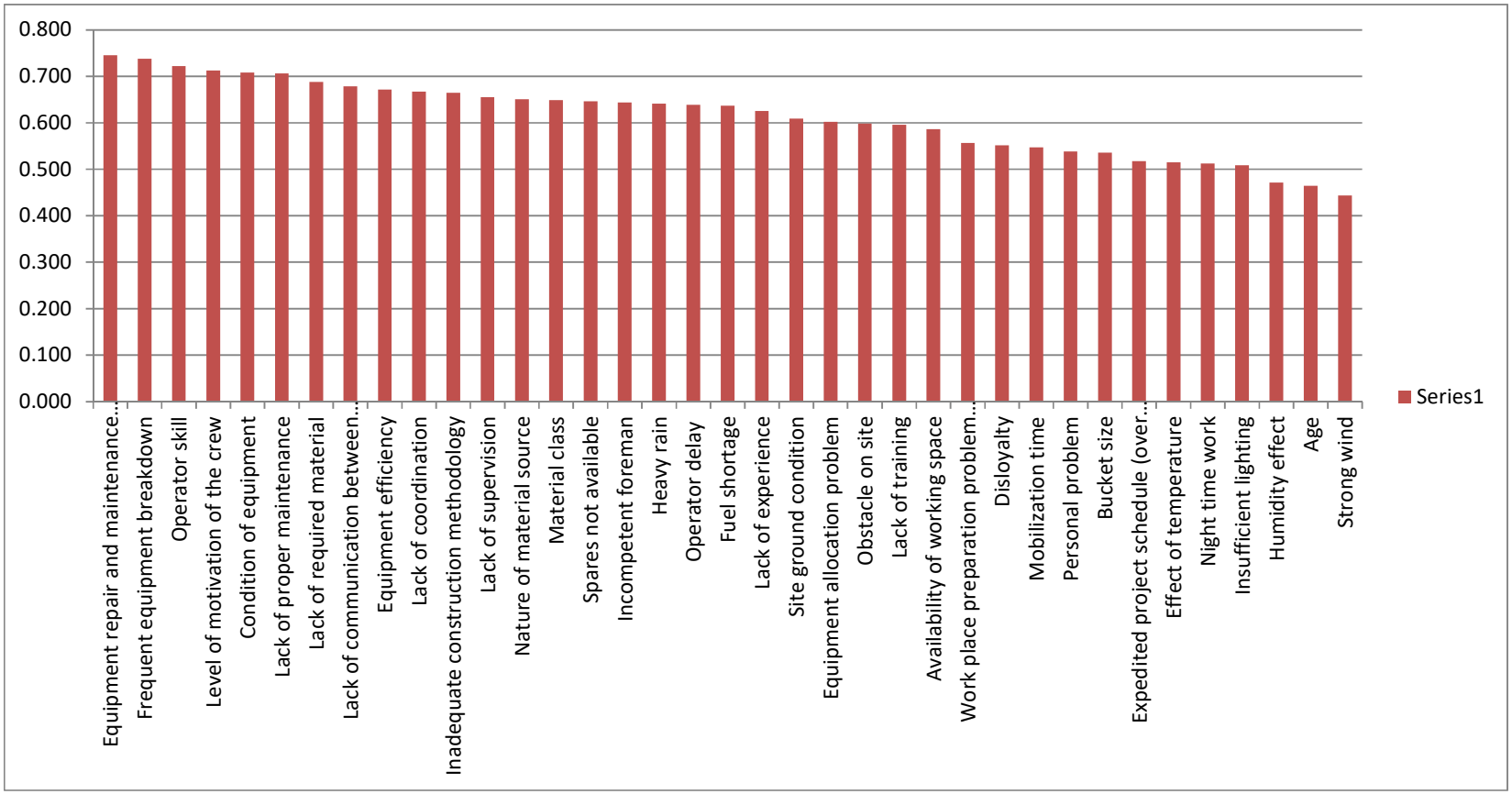

Figure-17 Overall Relative Importance Index and rank of all factors for Excavator

4.3.1 Efficiency Analysis for the four Asphalt Road Projects for Dozer

The three-day data of average operational hour and calculation of the equipment's efficiency based on the operational hour are summarized in Table 21

The operational hour of the equipment and their efficiency calculation sheets are attached to Appendix B

Table 21 Summary of Average operational hour and efficiency for four Asphalt Road Project (Dozer)

Equipment	Project name	Working Location	Average operational hour	Efficiency
Dozer	Bolebulbula Lot-1 Asphalt Road Project	(Borrow @ 1+520(Offset 800 RHS)	7.17hr	68.25%
	Bolebulbula Condominium Asphalt road Project	Borrow @ 1+520(Offset 600 RHS)	6.78hr	67.77%
	Bole Ayat Asphalt Road Project	Borrow @ 1+520(Offset 800 RHS)	7.36hr	70.1%
	Ararat - kotebe- kara Asphalt Road Project	Borrow @ 2+220(Offset 3km LHS)	7.45hr	67.69%

All the summary of efficiency calculation based on the operational hour is contained in Table 21. It shows that the average operational hour for the four projects is 7.19hr and with an average efficiency of 68.45% which is low comparing from the total working hour of the project. The result shows that the equipment is not performing well. For the Dozer due to the factor affecting the equipment productivity

4.3.2 Efficiency Analysis for the four Asphalt Road Projects for Excavator

The three-day data of average operational hour and calculation of the equipment's efficiency based on the operational hour are summarized in Table 22

The operational hour of the equipment and their efficiency calculation sheets are attached to Appendix B

Table 22 Summary of Average operational hour and efficiency for four Asphalt Road Project (Excavator)

Equipment	Project name	Working Location	Average operational hour	Efficiency
Excavator	Bolebulbula Lot-1 Asphalt Road Project	(Borrow @ 1+520(Offset 800 RHS)	8.11hr	77.24%
	Bolebulbula Condominium Asphalt road Project	Borrow @ 1+520(Offset 600 RHS)	7.59hr	75.87%
	Bole Ayat Asphalt Road Project	Borrow @ 1+520(Offset 800 RHS)	8.23hr	78.35%
	Ararat - kotebe- kara Asphalt Road Project	Borrow @ 2+220(Offset 3km LHS)	7.45hr	67.69%

All the summary of efficiency calculation based on the operational hour is contained in Table 22. It shows that the average operational hour for the four projects is 7.5hr and with an average efficiency of 74.79% which is low comparing from the total working hour of the project. The result shows that the equipment is not performing well. For the excavator due to the factor affecting the equipment productivity.

4.4. Analysis of main Contributing factors for the loss of productivity from the Actual Observation

4.4.1. Observed loss contributing factors for Dozer

The main observed factors for low productivity of earthwork equipment for Dozer are summarized in Table-23. It is possible to conclude that for all the four cases for dozer from actually observed factor in the sit the Equipment maintenance facilities problems were the critical factors in affecting earthwork equipment productivity in all projects and it was ranked first (i.e., 87.78%) among the main contributing factors. The second critical factor that affects earthwork equipment productivity on the four projects was the Equipment breakdown with the percentage of 57.27. Lack of proper maintenance and Lack of required material ranked as the third and fourth with a percentage of 43.91 and 42.69 in contributing to the Dozer productivity loss. Lack of motivation of the operator ranked in 5^{th} place with a percentage of 18.3. Lack of communication and Operator delay ranked in the 6^{th}, 7^{th} place with a percentage of 9.41, 2.5 respectively.

Table-23 Summary of Factors affecting the productivity of earthwork equipment for Dozer on the study projects

Equipment	Contributing Factor Observed	Non-working hour	Percentage of non-working hr
Dozer	Lack of communication	1hr	9.41%
	Equipment breakdown	6hr	57.27%
	Equipment maintenance facilities	9.09hr	87.78%
	Lack of motivation of the operator	1.92hr	18.3%
	Lack of proper maintenance	4.83hr	43.91%
	Operator delay	0.25hr	2.5%
	Lack of required material	4.42hr	42.69%

4.4.1. Observed loss contributing factors for Excavator

The main observed factors for low productivity of earthwork equipment for excavators are summarized in Table-24. It is possible to conclude that for all the four cases for excavator from actually observed factor in the sit the Equipment maintenance facilities problems were the critical factors in affecting earthwork equipment productivity in all projects and it was ranked first (i.e., 57.58%) among the main contributing factors. The second critical factor that affects earthwork equipment productivity on the four projects was the Lack of proper maintenance with the percentage of 43.91. Equipment breakdown and Lack of required material ranked as the third and fourth with a percentage of 36.56 and 31.57 in contributing to the Excavator productivity loss. Lack of motivation of the operator ranked in the 5th place with a percentage of 22.28. Incompetent foreman, fuel problem, Lack of communication ranked in the 6th, 7th, 8th place with a percentage of 7.14, 4.76, 2.27 respectively.

Table-24 Summary of Factors affecting the productivity of earthwork equipment for Excavator on the study projects

Equipment	Contributing Factor Observed	Non-working hour	Percentage of non-working hr
Excavator	Lack of motivation of the operator	2.33hr	22.28%
	Incompetent foreman	0.75hr	7.14%

	Equipment maintenance facilities	5.92hr	57.58%
	Equipment breakdown	3.83hr	36.56%
	Lack of required material	3.26hr	31.57%
	Fuel problem	0.5hr	4.76%
	Lack of communication	0.25hr	2.27%
	Lack of proper maintenance	4.83hr	43.91%

4.5 The effect of earthwork equipment efficiency on the progress of the road project

From the effeiceincy calculation, it is found that low effeiciency results from higher non working hours of the equipments which is coused due to the observed factors. This low efficiency affects the progress of the road projects and results in delay of the project. Hence, these factors will result in affecting the progress of the project.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In this research, about 37 factors affecting earthwork equipment productivity are identified. These factors were ranked according to their importance relative index from the viewpoint of different respondents including project managers, construction supervisors, engineers, and others who have experience in the road construction industry. Moreover, the efficiency of earthwork equipment is also checked by critical observation by recording operational hours of earthwork equipment in different projects.

The finding of the research indicates that the factors affecting earthwork equipment productivity in Addis Ababa city road authority projects are equipment factor, technical factor, operator factor, management factor, and environmental factor.

The research finding indicates that the efficiency of the earthwork equipment utilization in terms of operating time due have an influence on the productivity of earthwork equipment.

The research identified that the lesser the operating time per day of earthwork equipment will be the longer the project period to accomplish the project.

5.2 RECOMMENDATION

Based on the research of findings, the following recommendation is made:

- ✓ It is better to have a proper supply of spare parts and facilities nearby stores.
- ✓ It is better to trainee the management staff and equipment operator to improve their skill .
- ✓ Providing of incentives and recognition for all project staff.
- ✓ Updating operator technical knowledge and assembling standard spare parts also using mobile garage.
- ✓ Establishment of systematic equipment administration and follow up of equipment services time accordingly.

REFERENCES

[1]. Habenom, G.Z. Research in Ethiopian Construction Industry: Review of Past Studies and Future Need Assessment. Unpublished Master's thesis, Addis Ababa University.2017.

[2]. Wolday, A. Report on the Ethiopian Economy, Volume VI 2006/07the Current State of the Construction Industry. Ethiopian Economic Association (EEA). Printed in Addis Ababa, Ethiopia September 2008.

[3]. Mahamid, I.'Common risks affecting time overrun in road construction projects in Palestine: Contractors' perspective'. Australasian Journal of Construction Economics and Building.2013; 13 (2): 45-53

[4].Dushyant, A. D, and Parag, S. M. Assessment of Factors Affecting Productivity of Excavator. International Journal of Advanced Engineering and Research Development.2016; 3(5):455-462.

[5]. Mr. Deokar Kishor H &Dr. Mrs. Kulkarni Sushma S Factors influencing the productivity of construction equipment on site. JournalNX- A Multidisciplinary Peer Reviewed Journal (ISSN No:2581-4230).2018;77-79.

[6]. Sachin,p.*et al. A* critical review of the identification of critical factors affecting the productivity of construction equipment. International Journal of Engineering Research & Technology (IJERT).2017;6(2):279-301.

[7]. Rober W.Schober, Stefanie G.Brandenburg, and Lansford C.Bell (2008, August). "Optimal maintenance crew composition and enhancement of crew productivity. "SCDOT Research Project 668"

[8]. Dushyant, A.D, and Parag, S. M. Factors Affecting Performance of Excavating Equipment: An Overview. International Journal of Science and Research (IJSR). 2016;5(1):1250-1253.

[9]. A. Salah, A. Salem, and O. Moselhi, Automated Fuzzy Set-Based System for Monitoring the Effects of Productivity Variation on Earthmoving Projects. International Journal of Innovation, Management and Technology.2017;8(2):85-89.

[10].Peurifoy, R.L., W.B. Ledbetter, and C. J. Schexnayder, (2006).Construction Planning, Equipment and methods (7th ed.).New York: McGraw- Hill.

[11]. Yun-Yisu. "Construction Crew Productivity Monitoring Supported By," the

University of Illinois at Urbana-Champaign, 2010.

[12]. Hamed, N. R., an assessment of nominal and actual hourly production of the construction equipment based on several earth-fill dam projects in Iran. The Open Civil Engineering Journal. 2009;3:74-82.

[13].Michale A. Harber (1988). "Survey of productivity rates used for highway construction."M.Sc. Research, Department of Civil Engineering, University of Florida.

[14]. A. Sheikh, T. Nadu, M. Lakshmipathy, T.Nadu, " Application of Queuing Theory for Effective Equipment Utilization and Maximization of productivity in Construction Management," vol.11, no. 8, pp. 5664-5672, 2016.

[15]. A. Salem, *et al.* study of factors influencing the productivity of hauling equipment in earthmoving projects using fuzzy set theory. International Journal of Innovation, Management and Technology .2017;8(2):151-154.

[16]. J. Fu, Logistics of Earthmoving Operations Simulation and Optimization, no. June. 2013.

[17]. Afshan, S. *et al.* application of queuing theory for effective equipment utilization and maximization of productivity in construction management. International Journal of Applied Engineering Research.2016;11(8): 5664-5672.

[18]. Melese, M. Assessment of Factors Affecting Labor Productivity on Road Construction Projects in Oromia Region, Bale Zone. International Journal of Scientific and Engineering Research. 2016;7(11):899-910.

[19]. Saurav, D. A study of Enabling Factors Affecting Construction Productivity: Indian Scenario. International Journal of Civil Engineering and Technology (IJCIET).2017; 8(6): pp. 741–758.

[20].Hamed, N.R. *et al.* A Statistical-based Approach to Evaluate the Production of Crawler-type Dozer in Construction Projects. American Journal of Civil Engineering and Architecture. 2018; 6(2):80-92.

[21]. Isaac, A.O. Assessment of Management-Related Factors Affecting Construction Labour Productivity in the Cross River State of Nigeria. Covenant Journal of Research in the Built Environment (CJRBE).2015; 3(2):13-29.

[22]. Zhao, Y. Significant Factors Affecting Construction Productivity. Unpublished Master's thesis.National University of Singapore.2004.

[23]. Adel, A., and Osama, M. Productivity based method for forecasting cost & time of earthmoving operations using sampling GPS data. Journal of Information Technology in Construction (ITcon),2016; Vol. 21: 39-56,

[24]. D. B. Phadatare and S. B. Charhate.Impact of Construction Equipment on Building site Productivity. International Journal of Civil Engineering and Technology (IJCIET). 2016;7(4): pp. 513–520.

[25]. Nipin , J. B. Factors Affecting Success of Construction Project. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE). 2015;12(2): PP 17-26.

[26]. Priyanka, M. *et al.* Identification of factors influencing equipment productivity in construction projects. International Research Journal of Engineering and Technology (IRJET).2018;5(6):379-384.)

[27]. Mr. Mundane Sagar R. & Prof. Khare Pranay R. Comparative study of factors affecting productivity and cycle time of different excavators and their bucket size. International Journal on Recent and Innovation Trends in Computing and Communication.2015;3(12):6518-6520.

[28].Ok, S. C. and S. K. Sinha. "Construction equipment productivity estimation using artificial neural network model."Construction Management and Economics.2014; 24(10): 1029-1044.

[29]. Sheikh, A., and M. Lakshmipathy. "Application of Queuing Theory for Effective Equipment Utilization and Maximization of Productivity in Construction Management." International Journal of Applied Engineering Research.2016; 11(8): 5664-5672.

[30].Chetan, P.& Vivek, D. A Review on Improvement in Overall Equipment effectiveness. International Journal for Research in Applied Science & Engineering Technology (IJRASET).2016;4(*XI)* ;642-650.

APPENDIXES

APPENDIX A

Appendix A: Questionnaire for Research Thesis

JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDENT

JIMMA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL and ENVIRONMENTAL ENGINEERING

CONSTRUCTION ENGINEERING and MANAGEMENT

(QUESTIONNAIRE)

Assessment of the Factors Affecting Productivity of Earthwork Equipment in Addis Ababa City Road Authority Projects

Researcher: - Feven Fekede (MSc)
Advisor: - Bein Maunahan (Asst. Professor)
Co. Advisor: - Dr. Lucy Feleke

Dear respondents

The objective of this questionnaire is to collect data on the assessment of factors affecting the productivity of earthwork equipment in Addis Ababa city road authority projects. It will be used to prepare a thesis as partial fulfillment of a master's degree in construction engineering and management. You (respondent) are kindly requested to read the questioner thoroughly and respond accordingly. The result of this assessment will be treated with the utmost confidentiality and will be strictly used for academic purposes only.

Section -1 General Organizational Information

1. Name of organization: ----------

2. What is the grade of your company (contractor)? ----------

3.What is the Total project cost in ETB? ----------

Please put a tick mark □in the appropriate box.

4. Respondent organization (company Type)

Consultant □ Contractor □ Client□

5. What is your current position within the company?

Head of organization□ Project Manager □ Construction Engineer□ Office Engineer□

Site Engineer□ Site Supervisor□ Other_____

6. Relevant working experience (year)

□1-5yrs □6-10 yrs □11-15 yrs □16-20 yrs □more than20yrs

Section – 2: Please indicate to what extent the following factors affect the productivity of earthwork equipment.

According to the scope of the study, this questionnaire is prepared to obtain information about the following earthwork equipment.

1. Dozer
2. Excavator

Please indicate the significance of each factor by ticking the appropriate boxes

Level of the factors	Weight
Extremely significant (E.S.)	5
Very significant (V.S.)	4
Moderately significant (M.S.)	3
Slightly significant (S.S.)	2
Not significant (N.S.)	1

A1: For Dozer

NO	*How Significant do you think these factors affect the productivity of equipment?*	*Data measurement*				
A	***Environmental Factor***	1 (N.S)	2 (S.S)	3 (M.S)	4 (V.S)	5 (E.S)
	1. Effect of temperature	☐	☐	☐	☐	☐
	2. Availability of working space	☐	☐	☐	☐	☐
	3. Nature of material source	☐	☐	☐	☐	☐
	4. Humidity effect	☐	☐	☐	☐	☐
	5. Heavy rain	☐	☐	☐	☐	☐
	6. Site ground condition	☐	☐	☐	☐	☐
	7. Obstacle on site	☐	☐	☐	☐	☐
	8. Strong wind	☐	☐	☐	☐	☐
B	***Management Factor***					
	1. Lack of communication between operator and supervisor	☐	☐	☐	☐	☐
	2. Equipment repair and maintenance facilities	☐	☐	☐	☐	☐
	3. Equipment allocation problem	☐	☐	☐	☐	☐
	4. Lack of supervision	☐	☐	☐	☐	☐
	5. Inadequate construction methodology	☐	☐	☐	☐	☐
	6. Lack of proper maintenance	☐	☐	☐	☐	☐
	7. Incompetent foreman	☐	☐	☐	☐	☐
	8. Mobilization time	☐	☐	☐	☐	☐
	9. Fuel shortage	☐	☐	☐	☐	☐
	10. Lack of coordination	☐	☐	☐	☐	☐
	11. Insufficient lighting	☐	☐	☐	☐	☐
	12. Nighttime work	☐	☐	☐	☐	☐
	13. Expedited project schedule (overtime, extra shifts, more crew)	☐	☐	☐	☐	☐
	14. Workplace preparation problem (request for inspection, supervision, approval to proceed)	☐	☐	☐	☐	☐
C	***Operator Factor***					
	1. Operator skill	☐	☐	☐	☐	☐

	2. Lack of experience	☐	☐	☐	☐	☐
	3. Disloyalty	☐	☐	☐	☐	☐
	4. Age	☐	☐	☐	☐	☐
	5. Personal problem	☐	☐	☐	☐	☐
	6. Lack of training	☐	☐	☐	☐	☐
	7. Operator delay	☐	☐	☐	☐	☐
	8. Level of the motivation of the crew	☐	☐	☐	☐	☐
D	***Equipment Factor***					
	1. Condition of equipment	☐	☐	☐	☐	☐
	2. Equipment efficiency	☐	☐	☐	☐	☐
	3. Frequent equipment breakdown	☐	☐	☐	☐	☐
	4. Bucket size	☐	☐	☐	☐	☐
	5. Spares not available	☐	☐	☐	☐	☐
E	***Technical Factor***					
	1. Lack of required material	☐	☐	☐	☐	☐
	2. Material class	☐	☐	☐	☐	☐

A2: For Excavator

NO	*How Significant do you think these factors affect the productivity of equipment?*	*Data measurement*				
A	*Environmental Factor*	1 (N.S)	2 (S.S)	3 (M.S)	4 (V.S)	5 (E.S)
	1.Effect of temperature	☐	☐	☐	☐	☐
	2.Availability of working space	☐	☐	☐	☐	☐
	3. Nature of material source	☐	☐	☐	☐	☐
	4.Humidity effect	☐	☐	☐	☐	☐
	5.Heavy rain	☐	☐	☐	☐	☐
	6.Site ground condition	☐	☐	☐	☐	☐
	7.Obstacle on site	☐	☐	☐	☐	☐
	8.Strong wind	☐	☐	☐	☐	☐
B	*Management Factor*					
	1. Lack of communication between operator and supervisor	☐	☐	☐	☐	☐
	2.Equipment repair and maintenance facilities	☐	☐	☐	☐	☐
	3.Equipment allocation problem	☐	☐	☐	☐	☐
	4.Lack of supervision	☐	☐	☐	☐	☐
	5.Inadequate construction methodology	☐	☐	☐	☐	☐
	6.Lack of proper maintenance	☐	☐	☐	☐	☐
	7.Incompetent foreman	☐	☐	☐	☐	☐
	8.Mobilization time	☐	☐	☐	☐	☐
	9.Fuel shortage	☐	☐	☐	☐	☐
	10.Lack of coordination	☐	☐	☐	☐	☐
	11.Insufficient lighting	☐	☐	☐	☐	☐
	12.Nighttime work	☐	☐	☐	☐	☐
	13.Expedited project schedule (overtime, extra shifts, more crew)	☐	☐	☐	☐	☐
	14.Workplace preparation problem (request for inspection, supervision, approval for continuation)	☐	☐	☐	☐	☐
C	*Operator Factor*					
	1.Operator skill	☐	☐	☐	☐	☐
	2.Lack of experience	☐	☐	☐	☐	☐

	3.Disloyalty	☐	☐	☐	☐	☐
	4.Age	☐	☐	☐	☐	☐
	5.Personal problem	☐	☐	☐	☐	☐
	6.Lack of training	☐	☐	☐	☐	☐
	7.Operator delay	☐	☐	☐	☐	☐
	8.Level of the motivation of the crew	☐	☐	☐	☐	☐
D	***Equipment Factor***					
	1.Condition of equipment	☐	☐	☐	☐	☐
	2.Equipment efficiency	☐	☐	☐	☐	☐
	3.Frequent equipment breakdown	☐	☐	☐	☐	☐
	4.Bucket size	☐	☐	☐	☐	☐
	5.Spares not available	☐	☐	☐	☐	☐
E	***Technical Factor***					
	1.Lack of required material	☐	☐	☐	☐	☐
	2.Material class	☐	☐	☐	☐	☐

Section – 3 Other comments on factor affecting the productivity of earthwork (Dozer and Excavator) equipment at construction job sites

a) _____

b)_____

c)_____

d)_____

e)_____

Section -4 Please put a tick mark □ in the appropriate box.

1. Does earthwork equipment efficiency affect the progress of road projects?

Yes □ No □

2. To what extent will earthwork equipment efficiency affect the progress of the road projects?

Very high □ High □ Medium □ Low □ very low □

Thank you

Amharic Questionnaire

ጅማ ዩኒቨርሲቲ

ድህረ ምረቃ ትምህርት ክፍል

ጅማ ቴክኖሎጅ ኢንስቲትዩት

ሲቪል ና ኢንቫሮሜንታል ምህንድስና ትምህርት ቤት

የ ኮ ን ስ ት ራ ክ ሽ ን ምህ ን ድ ስ ና ና ማኔ ጅ መ ን ት ት ም ህ ር ት ዘ ር ፍ

(ሞጠይቅ)

በ አ ዲ ስ አ በ ባ ከ ተ ማ መ ን ገ ዶ ች ባ ለ ስ ል ጣ ን ስ ር በ ሚ ገ ኙ የ መ ን ገ ድ ስ ራ ፕ ሮ ጀ ክ ቶ ች ዉ ስ ጥ የ ኧ ር ዝ ወ ር ክ መ ሳ ሪ ያ ወ ች ን ም ር ታ ማ ነ ት ን የ ሚ ጎ ዱ ች ግ ሮ ች ን ለ ይ ቶ መ ሰ ብ ሰ ብ ና መ ፍ ት ሄ ዎ ቻ ቸ ዉ ን መ ጠ ቆ ም

ተ መ ራ ማ ሪ ፡ ፌ ቨ ን ፈ ቀ ደ
አ ማ ካ ሪ ፡ ቢ ን ማ ዉ ና ሃ ን (ረ ዳ ት ፕ ሮ ፌ ሰ ር)
ረ ዳ ት አ ማ ካ ሪ ፡ ሉ ሲ ፈ ለ ቀ (እ ጩ ዶ ክ ተ ር)

የ ዚ ህ መ ጠ ይ ቅ ዋ ና አ ላ ማ በ አ ዲ ስ አ በ ባ ከ ተ ማ መ ን ገ ዶ ች ባ ለ ስ ል ጣ ን ስ ር በ ሚ ገ ኙ የ መ ን ገ ድ ስ ራ ፕ ሮ ጀ ክ ቶ ች ዉ ስ ጥ የ ኧ ር ዝ ወ ር ክ መ ሳ ሪ ያ ወ ች ን ም ር ታ ማ ነ ት ን የ ሚ ጎ ዱ ች ግ ሮ ች ን ለ ይ ቶ መ ሰ ብ ሰ ብ ና መ ፍ ት ሄ ዎ ቻ ቸ ዉ ን መ ጠ ቆ ም ነ ዉ ፡ ፡ የ ዚ ህ ጥ ና ት ዉ ጤ ት የ ሚ ዉ ለ ዉ ከ ጅ ማ ዩ ኒ ቨ ር ሲ ቲ-ጅ ማ ቴ ክ ኖ ሎ ጅ ኢ ን ስ ቲ ት ዩ በ ሲ ቪ ል ምህ ን ድ ስ ና ስ ር በ ኮ ን ስ ት ራ ክ ሽ ን ምህ ን ድ ስ ና ና ማ ኔ ጅ መ ን ት ማ ስ ተ ር ስ ኦ ፍ ሳ ይ ን ስ (M.Sc.) ለ ሞ ቀ በ ል የ ሚ ዉ ል ነ ዉ፡ ይ ህ መ ጠ ይ ቅ በ ተ ቻ ለ መ ጠ ን በ እ ዉ ነ ተ ኛ ና ት ክ ክ ለ ኛ መ ረ ጃ መ ሞ ላ ት አ ለ በ ት፡ ፡ ከ ዚ ህ መ ጠ ይ ቅ የ ሚ ገ ኝ መ ረ ጃ የ ሚ ዉ ለ ዉ ለ አ ካ ዳ ሚ ክ ሪ ሰ ር ች (ት ም ህ ር ታ ዊ ጥ ና ት) ብ ቻ ና ሚ ስ ጥ ራ ዊ ነ ቱ በ ጣ ም የ ተ ጠ በ ቀ ነ ዉ፡ ፡

ሀ . ት ዕ ዛ ዝ

✓ ይህ መጠይቅ ሁለት ክፍሎች ኣሉት፡ ፡ የመጀመርያዉስለ ጠቅላላ እንፎርሜሽን ስሆን ሁለተኛዉደግሞየ ኧርዝ ወርክ መሳሪያወችን ምርታማነ ትን የሚነዱ ችግሮችን ደረጃ ስለ መስጠት ይሆናል፡ ፡ በሁለቱምክፍሎች ስር የሚገኙትን ጥያቄዎች ተገቢዉን መልስ በተሰጠዉባዶ ቦታ ላይ በትክክል ና በንፅህና እንዲመልሱ በትህትና እጠይቃለሁ፡ ፡

✓ ተመራማሪዉን ወዳልሆነ ድምዳሜየ ሚያደረስ መረጃ መፃ ፍ ፈፅ ሞ ኣይፈለግም፡ ፡

<u>ለ.ክፍል ኣንድ</u>፡ -ጠቅላላ ኢንፎርሜሽን

1) የድርጅቱ ስም_____

2) የድርጅቱ ደረጃ(ኮንትራክተር)_____

3) የፕሮጀክቱ ጠቅላላ በጀት በ ኢትዮጵያ ብር

_____

ከዚህ ስር ለሚገኙትን ጥያቄዎች ተገቢዉን መልስ በተሰጠዉሳጥን ውስጥየ (x) ምልክት ያስቀምጡ፡ ፡

4) የ ድርጅቱ (የ ካምፓኒ ውአይነት)

ኮንሰልታነት ☐ ኮንትራክተር ☐ ክልያንት ☐

5)በሚሰሩበት መስሪያቤት/ካምፓኒ የእርሶ የስራ ድርሻ ምንድንነዉ?

ፕሮጀክት ማኔጀር/ዲፕዩት ፕሮጀክት ማኔጀር ☐ ኮንስትራክሽን ኢንጅነር ☐ ኦፊስኢንጅነር ☐

ሳይት ኢንጅነር ☐ ሳይት ሱፐርቫይዘር ☐ ኦፕሬተር ☐ ሌላ

_____

6)በ መንገድ ኮንስትራክሽን ዉስጥ ለስንት ኣመት ሰርተዋል?

ከ 0 - 5 አመት ☐ ከ 6 - 10 አመት ☐ ከ 11 - 15 አመት ☐ ከ 16 - 15 አመት ☐ ከ 20 አመት በላይ ☐

ሐ.ክፍል ሁለት

✓ ከዚህ በታች የተዘረዘሩትን በመንገድ ስራ ዉስጥ የኧርዝ ወርክ መሳሪያወችን ምርታማነ ትን የሚነዱ ችግሮችን በምን ኣይነ ት ደረጃ ተፅኖ እንደሚያደረሱ ከተዘረዘሩት የደረጃ መስጫ ጥኖች ዉስጥ የራሶን ልምድ ና የስራ ገጠሞኝ በመጠቀም በኣንዱ ዉስጥ ምልክት ያድርጉ፡ ፡

✓ ያስተዉሉ በአንዱ ሳጥን ዉስጥ ምልክት ሲያደርጉ፡ -

1) በጣም ዝቅተኛ---ችግሩ የእርዝ ወርክ መሳሪያወችን ምርታማነት የሚነዳዉ በጣም ዝቅተኛ በሆነ መልክ ነዉ

2) ዝቅተኛ -------- ችግሩ የእርዝ ወርክ መሳሪያወችን ምርታማነት የሚነዳዉ ዝቅተኛ በሆነ መልክ ነዉ

3) መካከለኛ----ችግሩ በእርዝ ወርክ መሳሪያወች ምርታማነት ለይ መካከለኛ ተፅኖ አለዉ

4) ከፍተኛ------ ችግሩ የእርዝ ወርክ መሳሪያወችን ምርታማነት የሚነዳዉከፍተኛ በሆነ መልክ ነዉ

5) በጣም ከፍተኛ--ችግሩ የእርዝ ወርክ መሳሪያወችን ምርታማነት የሚነዳዉ በጣም ከፍተኛ በሆነ መልክ ነዉ

✓ ከዚህ በታች በአዲስ አበባ ከተማ መንገዶች ባለስልጣን ስር በሚገኙ የመንገድ ስራ ፕሮጀክቶች ዉስጥ የእርዝ ወርክ (ዶዘር ና ኤክስካቫተር)መሳሪያወችን ምርታማነትን ሊጎዱ የሚችሉ ችግሮች ተለይተዉ ተዘርዝረዋል፡ ፡ የራሶን ልምድ ና የስራ ገጠመኝ በመጠቀም የችግሩን ደረጃ በማመዛዘን በአንዱ ዉስጥ ምልክት ያድርጉ፡ ፡

ሐ1፡ ለ ዶዘር

ተ.ቁ	የዶዘርን ምርታማነትን የሚነዱ ችግሮች	የመረጃ መላኪያ				
ሀ	የተፈጥሮ/በአካባቢ ምክንያት	በጣም ዝቅተኛ (1)	ዝቅተኛ (2)	መካከለኛ (3)	ከፍተኛ (4)	በጣም ከፍተኛ (5)
	1. የመቀትና ቅዝቃዜ ተጽኖ	☐	☐	☐	☐	☐
	2.በቂ የመስሪያ ቦታ አለመኖር	☐	☐	☐	☐	☐
	3.የማቴሪያል ሶርሱ ተፈጥሮ	☐	☐	☐	☐	☐
	4.የአየር እርጥበት ተጽኖ	☐	☐	☐	☐	☐
	5.ከባድ ዝናብ	☐	☐	☐	☐	☐
	6.የሳይት ስራ ቦታ አቀማመጥ	☐	☐	☐	☐	☐
	7.ሳይት ውስጥ ያሉ እንቅፋቶች	☐	☐	☐	☐	☐

	8.ከባድ ንፋስ	☐	☐	☐	☐	☐
ለ	**የ ማሄ ጅመንት ችግር**					
	1.በ ኦፕሬተር ና በተቆጣጣሪ መሀል በቂ ያልሆነ ግንኙነ ት	☐	☐	☐	☐	☐
	2.የ ጥገ ና ና የ መለ ዋወጫእ ቃወች አ ቅር ቦ ት ማነ ስ	☐	☐	☐	☐	☐
	3.የ ኢኩፕ መን ት አ መዳ ደብ ችግ ር	☐	☐	☐	☐	☐
	4.የ ቁ ጥጥ ር ማነ ስ	☐	☐	☐	☐	☐
	5.በ ቂ ያ ልሆ ነ የ ኮ ን ስ ት ራ ክ ሽ ን ስ ል ት	☐	☐	☐	☐	☐
	6.ወ ቅ ታ ዊ ጥ ገ ና አ ለ ማ ግ ኘ ት	☐	☐	☐	☐	☐
	7.ብ ቃ ት የ ሌ ለ ው አ ሰ ሪ (ፎ ር ማ ን)	☐	☐	☐	☐	☐
	8.የ መ ሳ ሪ ያ ና የ ሰ ው ሀ ይ ል የ ማ ን ቀ ሳ ቀ ሻ ግ ዜ	☐	☐	☐	☐	☐
	9.የ ነ ዳ ጅ እ ጥ ረ ት	☐	☐	☐	☐	☐
	10.የ ቅ ን ጅ ት ማነ ስ	☐	☐	☐	☐	☐
	11.የ ብ ር ሀ ን እ ጥ ረ ት	☐	☐	☐	☐	☐
	12.የ ማታ ሽ ፍ ት ስ ራ	☐	☐	☐	☐	☐
	13.የ ተ ፋ ጠ ነ የ ጊ ዜ ሰ ሌ ዳ (ከ ስ ራ ሰ አ ት በ ላ ይ ፣ ተ ጨ ማ ሪ ሽ ፍ ት ፣ ብ ዙ የ ስ ራ ቡ ድ ን)	☐	☐	☐	☐	☐
	14.የ ስ ራ ቦ ታ ዝ ግ ጅ ት ች ግ ሮ ች (የ ግ ምገ ማ ና የ ክ ት ት ል ጥ ያ ቄ ፣ ማ ጽ ደ ቅ ና ስ ራ ው እ ን ዲ ቀ ጥ ል የ ማ ድ ረ ግ ች ግ ር)	☐	☐	☐	☐	☐
ሐ	**በ ኦ ፕ ሬ ተ ር ም ክ ን ያ ት**					
	1.ኦ ፕ ሬ ተ ር ች ሎ ታ	☐	☐	☐	☐	☐
	2.የ ል ም ድ ማ ጣ ት	☐	☐	☐	☐	☐
	3.አ ለ መ ታ መ ን	☐	☐	☐	☐	☐
	4.እ ድ ሜ	☐	☐	☐	☐	☐
	5.የ ኦ ፕ ሬ ተ ር የ ግ ል ች ግ ር	☐	☐	☐	☐	☐
	6.የ ኦ ፕ ሬ ተ ር ተ ገ ቢ ስ ል ጠ ና ማ ጣ ት	☐	☐	☐	☐	☐
	7.የ ኦ ፕ ሬ ተ ር በ ሰ አ ት አ ለ መ ገ ኘ ት	☐	☐	☐	☐	☐
	8.የ ስ ራ ተ ነ ሳ ሽ ነ ት ደ ረ ጃ	☐	☐	☐	☐	☐
መ	**በ ኢ ኩ ፕ መ ን ት ም ክ ን ያ ት**					
	1.የ ኢኩ ፕ መ ን ቱ ያ ለ በ ት ሁ ኔ ታ	☐	☐	☐	☐	☐
	2.ኢ ኩ ፕ መ ን ት ኢ ፊ ሸ ን ሲ (ብ ቃ ት)	☐	☐	☐	☐	☐
	3.በ ተ ደ ጋ ጋ ሚ የ ኢ ኩ ፕ መ ን ት መ በ ላ ሸ ት (መ ሰ በ ር)	☐	☐	☐	☐	☐

	4.የ አ ካ ፋ ው ጦጠን	☐	☐	☐	☐	☐
	5.የ ሞለ ዋ ወ ጫእ ቃ አ ለ ሞግ ኘ ት	☐	☐	☐	☐	☐
ሰ	***በ ቴክ ኒ ካ ል ምክ ን ያ ት***					
	1.የ ተ ፈ ላ ጊ ማቴ ሪ ያ ል እ ጥ ረ ት	☐	☐	☐	☐	☐
	2.የ ማቴ ሪ ያ ሉ አ ይነ ት (ሞደ ብ)	☐	☐	☐	☐	☐

ሐ2፡ ለ ኤ ክ ስ ካ ቫ ተ ር

ተ. ቁ	***የ ኤ ክ ስ ካ ቫ ተ ር ን ምር ታ ማነ ት ን የ ሚነ ዱ ችግ ሮ ች***	***የ ሚ ያ ሟ ላ ኪ ያ***				
ሀ	***የ ተ ፈ ጥሮ/ በ አ ካ ባ ቢ ምክ ን ያ ት***	በ ጣም ዝ ቅ ተ ኛ (1)	ዝ ቅ ተ ኛ (2)	መካ ከ ለ ኛ (3)	ከ ፍ ተ ኛ (4)	በ ጣም ከ ፍ ተ ኛ (5)

	1. የ ሙቀትና ቅዝቃዜ ተጽኖ	☐	☐	☐	☐	☐
	2. በቂ የ ሚስሪያ ቦታ አለ ሞኖር	☐	☐	☐	☐	☐
	3. የ ማቴሪያል ሶርሱ ተፈጥሮ	☐	☐	☐	☐	☐
	4.የ አየር እርጥበት ተጽኖ	☐	☐	☐	☐	☐
	5.ከባድ ዝናብ	☐	☐	☐	☐	☐
	6. የ ሳይት ስራ ቦታ አቀማመጥ	☐	☐	☐	☐	☐
	7.ሳይት ውስጥ ያሉ እንቅፋቶች	☐	☐	☐	☐	☐
	8.ከባድ ንፋስ	☐	☐	☐	☐	☐
ለ	***የ ማሄ ጅመንት ቾግር***					
	1.በ ኦፕሬተር ና በተቆጣጣሪ መሀል በቂ ያልሆነ ግንኙነት	☐	☐	☐	☐	☐
	2.የ ጥገና ና የ መለዋወጫእቃወች አቅርቦት ማነስ	☐	☐	☐	☐	☐
	3.የ ኢኩፕመንት አመዳደብ ችግር	☐	☐	☐	☐	☐
	4.የ ቁጥጥር ማነስ	☐	☐	☐	☐	☐
	5. በቂ ያልሆነ የ ኮንስትራክሽን ስልት	☐	☐	☐	☐	☐
	6. ወቅታዊ ጥገና አለ ማግኘት	☐	☐	☐	☐	☐
	7. ብቃት የ ሌለ ውተቆጣጣሪ	☐	☐	☐	☐	☐
	8. የ መሳሪያ ና የ ሰውሀይል የ ማንቀሳቀሻ ግዜ	☐	☐	☐	☐	☐
	9. የ ነዳጅ እጥረት	☐	☐	☐	☐	☐
	10. የ ቅንጅት ማነስ	☐	☐	☐	☐	☐
	11. የ ብርሀን እጥረት	☐	☐	☐	☐	☐
	12. የ ማታ ሽፍት ስራ	☐	☐	☐	☐	☐
	13.የ ተፋጠነ የ ጊዜ ሰሌዳ (ከ ስራ ሰአት በላይ፣ ተጨማሪ ሽፍት፣ ብዙ የ ስራ ቡድን)	☐	☐	☐	☐	☐
	14. የ ስራ ቦታ ዝግጅት ችግሮች (የ ግምገማና የ ክትትል ጥያቄ፣ ማጽደቅና ስራውእንዲቀጥል የ ማድረግ ችግር)	☐	☐	☐	☐	☐
ሐ	***በ ኦፕሬተር ምክንያት***					
	1. ኦፕሬተር ችሎታ	☐	☐	☐	☐	☐
	2. የ ልምድ ማጣት	☐	☐	☐	☐	☐
	3. አለ መታመን	☐	☐	☐	☐	☐
	4. እድሜ	☐	☐	☐	☐	☐
	5. የ ኦፕሬተር የ ግል ችግር	☐	☐	☐	☐	☐

	6. የ ኦ ፕ ሬ ተ ር ተ ገ ቢ ስ ል ጠ ና ማ ጣ ት	☐	☐	☐	☐	☐
	7. የ ኦ ፕ ሬ ተ ር በ ሰ አ ት አ ለ ማ ኘ ት	☐	☐	☐	☐	☐
	8. የ ስ ራ ተ ነ ሳ ሽ ነ ት ደ ረ ጃ	☐	☐	☐	☐	☐
መ	***በ ኢ ኩ ፕ መ ን ት ምክ ን ያ ት***					
	1. የ ኢ ኩ ፕ መ ን ቱ ያ ለ በ ት ሁ ኔ ታ	☐	☐	☐	☐	☐
	2. ኢ ኩ ፕ መ ን ት ኢ ፊ ሸ ን ሲ (ብ ቃ ት)	☐	☐	☐	☐	☐
	3. በ ተ ደ ጋ ጋ ሚ የ ኢ ኩ ፕ መ ን ት መ በ ላ ሸ ት (መ ሰ በ ር)	☐	☐	☐	☐	☐
	4. የ አ ካ ፋ ው መ ጠ ን	☐	☐	☐	☐	☐
	5. የ መ ለ ዋ ወ ጪ እ ቃ አ ለ ማ ኘ ት	☐	☐	☐	☐	☐
ሰ	***በ ቴ ክ ኒ ካ ል ምክ ን ያ ት***					
	1. የ ተ ፈ ላ ጊ ማ ቴ ሪ ያ ል እ ጥ ረ ት	☐	☐	☐	☐	☐
	2. የ ማ ቴ ሪ ያ ሉ አ ይ ነ ት (መ ደ ብ)	☐	☐	☐	☐	☐

መ) በ መ ን ገ ድ ስ ራ ዉ ስ ጥ የ እ ር ዝ ወ ር ክ (ዶ ዘ ር ና ኤ ክ ስ ካ ቫ ተ ር)መ ሳ ሪ ያ ዎ ች ም ር ታ ማ ነ ት ን የ ሚ ጎ ዱ ች ግ ሮ ች በ ተ መ ለ ከ ተ ማ ን ኛ ዉ ም አ ስ ታ የ ት ካ ሎ ት

ሀ)_____

ለ)_____

_____

ሐ)_____

_____

መ)_____

_____

ሰ) የ ራ ሶ ን ል ም ድ ና የ ስ ራ ገ ጠ ሜ ኝ በ መ ጠ ቀ ም ከ ዚ ህ ስ ር ለ ሚ ገ ኙ ት ን ጥ ያ ቄ ዎ ች ተ ገ ቢ ዉ ን መ ል ስ በ ተ ሰ ጠ ዉ ሳ ጥ ን ዉ ስ ጥ የ (x) ም ል ክ ት ያ ስ ቀ ም ጡ ፡

1. የ ኧ ር ዝ ወ ር ክ (ዶ ዘ ር ና ኤ ክ ስ ካ ቫ ተ ር) መ ሳ ሪ ያ ዎ ች ብ ቃ ት የ መ ን ገ ድ ፕ ሮ ጀ ክ ት ስ ራ ሂ ደ ት ላ ይ ተ ጽ ኖ አ ለ ዉ

አ ዎ ☐ አ ይ ☐

2.የ ኧ ር ዝ ወ ር ክ (ዶ ዘ ር ና ኤ ክ ስ ካ ቫ ተ ር) መ ሳ ሪ ያ ዎ ች ብ ቃ ት በ መ ን ገ ድ ፕ ሮ ጀ ክ ት ስ ራ ሂ ደ ት ላ ይ ያ ላ ቸ ዉ ተ ጽ ኖ እ ስ ከ ም ን ድ ረ ስ ነ ዉ ፡

በ ጣ ም ከ ፍ ተ ኛ ☐ ከ ፍ ተ ኛ ☐ መ ካ ከ ለ ኛ ☐ ዝ ቅ ተ ኛ ☐ በ ጣ ም ዝ ቅ ተ ኛ ☐

እ ና መ ሰ ግ ለ ን.

APPENDIX B

APPENDIX-B : Sample Format for Data Collection

Equipment Type: - *Dozer*

Name of Contactor:- *Fal General Contactor* Project Name:-*Bolebulbula Lot-1 Asphalt Road Project* Date:- *Nov, 03,2019*

Equipment Type: - Dozer Mark : - CAT Model:- *D8R* Plate no.:-_____

Working Location:- *Borrow @ 1+520(Offset 800 RHS)* Working Time:- *From 1:30 - 12:00* Working hour per day: ***10:30***

Operational Hr.		Total Operational Hour	Idle Hr		Total Idle Hour	Down Hr.		Total Down Hour	Contributing Factor
Start	End		Start	End		Start	End		
			1:30	2:00	30min				Lack of communication
2:00	4:40	2:40							
						4:40	5:10	30min	Equipment breakdown
5:10	6:00	50min							
									6:00 - 7:00 Lunchtime
			7:00	7:15	15min				Lack of motivation of the operator
7:15	12:00	4:45							
Total operational (Hour)		8.25	Total Idle (Hour)		0.75	Total breakdown (Hour)		0.5	

Equipment Type: - *Excavator*

Name of Contactor:- *Fal General Contactor* Project Name:-*Bolebulbula Lot-1 Asphalt Road Project* Date:- *Nov, 05,2019*

Equipment Type: - Excavator Mark : - HITACHI Model:_____ Plate no.:-_____

Working Location:- *Borrow @ 1+520(Offset 800 RHS)* Working Time:- *From 1:30 - 12:00* Working hour per day: 10*:30*

Operational Hr.		Total Operational Hour	Idle Hr		Total Idle Hour	Down Hr.		Total Down Hour	Contributing Factor
Start	End		Start	End		Start	End		
			1:30	1:40	10min				Lack of motivation of the operator
1:40	5:40	4:00							
			5:40	6:00	20min				Lack of motivation of the operator
									6:00 - 7:00 Lunchtime
7:00	10:45	3:45min							
						10:45	12:00	1:15min	Equipment breakdown
Total operational (Hour)		7.75	Total Idle (Hour)		0.50	Total breakdown (Hour)		1.25	

Efficiency = 7.75/10.50*100

Efficiency = 73.81%

Equipment Type: - *Dozer*

Name of Contactor:- *Crossland General Contactor* Project Name :-*Bolebulbula Condominium Asphalt road Project* Date:- *Nov, 06,2019*

Equipment Type: - Dozer Mark : - CAT Model:- *D8R* Plate no.:-_____

Working Location:- *Borrow @ 1+520(Offset 600 RHS)* Working Time:- *From 2:00 - 12:00* Working hour per day: *10:00*

Operational Hr.		Total Operational Hour	Idle Hr		Total Idle Hour	Down Hr.		Total Down Hour	Contributing Factor
Start	End		Start	End		Start	End		
2:00	6:00	4hr							
									6:00 - 7:00 Lunch time
			7:00	7:20	20min				Lack of motivation of the operator
7:20	10:35	3:15							
						10:35	12:00	1:25	Equipment breakdown
Total operationa (Hour)		7:25	Total Idle (Hour)		0.33	Total breakdown (Hour)		1:42	

Equipment Type: - *Excavator*

Name of Contactor:- *Crossland General Contactor* Project Name :-*Bolebulbula Condominium Asphalt road Project* Date:- *Nov, 06,2019*

Equipment Type: - Excavator Mark : - DOOSAN Model:- _____ Plate no.:-_____

Working Location:- *Borrow @ 1+520(Offset 600 RHS)* Working Time:- *From 2:00 - 12:00* Working hour per day: *10:00*

Operational Hr.		Total Operational Hour	Idle Hr		Total Idle Hour	Down Hr.		Total Down Hour	Contributing Factor
Start	End		Start	End		Start	End		
			2:00	2:30	30min				Lack of motivation of operator & foreman
2:30	6:00	3:30min							
									6:00 - 7:00 Lunch time
7:00	10:55	3:55min							
			10:55	12:00	1:05min				Lack of required material
Total operationa (Hour)		7:42	Total Idle (Hour)		1:58	Total breakdown (Hour)			

Equipment Type: - *Dozer*

Name of Contactor:- *Fal General Contactor* Project Name :-*Bole Ayat Asphalt Road Project* Date:- *Nov, 10,2019*
Equipment Type: - Dozer Mark : - CAT Model:- *D8R* Plate no.:-_____
Working Location:- *Borrow @ 1+520(Offset 800 RHS)* Working Time:- *From 1:30 - 12:00* Working hour per day: *10:30*

Operational Hr.		Total Operational Hour	Idle Hr		Total Idle Hour	Down Hr.		Total Down Hour	Contributing Factor
Start	End		Start	End		Start	End		
1:30	6:00	4:30							
									6:00 - 7:00 Lunch time
			7:00	7:25	25min				Lack of motivation of the operator
7:25	11:00	3:35							
			11:00	12:00	1:00				Lack of required material
Total operationa (Hour)		8:01	Total Idle (Hour)		1:42	Total breakdown (Hour)			

Equipment Type: - *Excavator*

Name of Contactor:- *Fal General Contactor* Project Name :-*Bole Ayat Asphalt Road Project* Date:- *Nov, 11,2019*

Equipment Type: - Excavator Mark : - HITACHI Model:- Plate no.:-_____

Working Location:- *Borrow @ 1+520(Offset 800 RHS)* Working Time:- *From 1:30 - 12:00* Working hour per day: *10:30*

Operational Hr.		Total Operational Hour	Idle Hr		Total Idle Hour	Down Hr.		Total Down Hour	Contributing Factor
Start	End		Start	End		Start	End		
			1:30	2:50	1:20min				Lack of required material
2:50	6:00	3:10							
									6:00 - 7:00 Lunch time
			7:00	7:25	25min				Incometent foreman (Delay of foreman)
7:25	12:00	4:35							
Total operationa (Hour)		7:75	Total Idle (Hour)		1:75	Total breakdown (Hour)			

Equipment Type: - *Dozer*

Name of Contactor:- *Driba Defersha General Contactor* Project Name :-*Ararat - kotebe- kara Asphalt Road Project*
Date:- *Nov, 13,2019*

Equipment Type: - Dozer Mark : - CAT Model:- *D8R* Plate no.:-_____

Working Location:- *Borrow @ 2+220(Offset 3km LHS)* Working Time:- *From 1:00 - 12:00* Working hour per day: *11:00*

Operational Hr.		Total Operational Hour	Idle Hr		Total Idle Hour	Down Hr.		Total Down Hour	Contributing Factor
Start	End		Start	End		Start	End		
1:00	6:00	5:00							
									6:00 - 7:00 Lunch time
			7:00	7:20	20min				Lack of motivation of the operator
7:20	9:45	2:25							
						9:45	11:00	1:15	Equipment breakdown
						11:00	12:00	1:00	Equipment maintenance facility
Total operationa (Hour)		7:42	Total Idle (Hour)		0.33	Total breakdown (Hour)		2:25	

Equipment Type: - *Excavator*

Name of Contactor:- *Driba Defersha General Contactor* Project Name :-*Ararat - kotebe- kara Asphalt Road Project*
Date:- *Nov, 14,2019*

Equipment Type: - Excavator Mark : - CAT Model:- *D8R* Plate no.:-_____

Working Location:- *Borrow @ 2+220(Offset 3km LHS)* Working Time:- *From 1:00 - 12:00* Working hour per day: *11:00*

Operational Hr.		Total Operational Hour	Idle Hr		Total Idle Hour	Down Hr.		Total Down Hour	Contributing Factor
Start	End		Start	End		Start	End		
1:00	2:25	1:25min							
						2:25	6:00	3:35	Lack of proper maintenance
									6:00 - 7:00 Lunch time
						7:00	8:15	1:15min	Lack of proper maintenance
8:15	12:00	3:45min							
Total operationa (Hour)		5:17	Total Idle (Hour)			Total breakdown (Hour)		4:83	

Efficiency =

APPENDIX C

Appendix C : Statistical Test for Response of Projects

Item Statistics

	Mean	Std. Deviation	N
Project 1	9.9655	3.89229	87
Project 2	13.6322	4.42539	87
Project 3	13.3333	4.65724	87
Project 4	10.1609	3.46032	87
Project 5	13.0690	4.97854	87
Project 6	9.6552	4.23119	87
Project 7	10.6322	2.96144	87
Project 8	11.1264	4.52334	87
Project 9	11.5057	4.42738	87
Project 10	13.0115	4.27946	87
Project 11	9.9770	3.55350	87
Project 12	11.0345	3.87733	87
Project 13	10.5632	3.61747	87

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	98.862	98.862	98.862	.000	1.000	.000	13
Item Variances	523.027	523.027	523.027	.000	1.000	.000	13

Inter-Item Correlation Matrix

	project 1	project 2	project 3	project 4	project 5	project 6	project 7	project 8	project 9	project 10	project 11	project 12	project 13
project 1	1.000	.702	.608	.505	.537	.500	.986	.915	.943	.919	.930	.921	.930
project 2	.702	1.000	.834	.693	.614	.502	.439	.878	.380	.086	.075	.942	.347
project 3	.608	.834	1.000	.775	.527	.451	.991	.757	.315	.121	.154	.903	.279
project 4	.505	.693	.775	1.000	.655	.422	.929	.135	.198	.860	.875	.808	.863
project 5	.537	.614	.527	.655	1.000	.681	.812	.852	.823	.840	.803	.805	.820
project 6	.500	.502	.451	.422	.681	1.000	.449	.018	.078	.205	.119	.977	.148
project 7	.986	.439	.991	.929	.912	.449	1.000	.717	.558	.967	.912	.925	.632
project 8	.915	.878	.257	.135	.852	.018	.717	1.000	.803	.002	.130	.933	.701
project 9	.943	.380	.315	.198	.823	.078	.558	.803	1.000	.111	.075	.923	.528
project 10	.919	.086	.121	.860	.840	.205	.967	.002	.111	1.000	.310	.721	.081
project 11	.930	.075	.154	.875	.803	.119	.912	.130	.075	.310	1.000	.952	.433
project 12	.921	.942	.903	.808	.805	.977	.925	.933	.923	.721	.952	1.000	.911
project 13	.930	.347	.279	.863	.820	.148	.632	.701	.528	.081	.433	.911	1.000