

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**



ADDIS ABABA UNIVERSITY
School of Graduate Studies
Institute of Technology

**ROOT CAUSES AND IMPACTS OF FREQUENT EXCAVATIONS TO
EXISTING CITY INFRASTRUCTURE:
A CASE OF ADDIS ABABA CITY STREETS AND UTILITY ASSETS**

**A Thesis Submitted to the School of Graduate Studies of Addis Ababa
University in Partial Fulfillment of the Requirements for
Degree of Master of Science in Construction Technology and Management
(Civil Engineering)**

Author: Fufa Lencho

Advisor: Robeam Solomon, PhD

June, 2024

Addis Ababa, Ethiopia

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

ADDIS ABABA UNIVERSITY
School of Graduate Studies
Institute of Technology

**ROOT CAUSES AND IMPACTS OF FREQUENT EXCAVATIONS TO EXISTING
CITY INFRASTRUCTURE:
A CASE OF ADDIS ABABA CITY STREETS & UTILITY ASSETS**

By: Fufa Lencho

Approved by Board of Examiners:

Robean S. Lemo (PhD) _____
Advisor signature date

Girmay Kahsay _____
External examiner signature date 1/10/24

ABRAMANA ASSEFA _____
Internal examiner signature date 10/02/24

Abrham Gebre (Dr.)
Dean, School of Civil &
Environmental Engineering

Chairman signature date



**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

DECLARATION

I declare that this thesis entitled “**ROOT CAUSES AND IMPACTS OF FREQUENT EXCAVATIONS TO EXISTING CITY INFRASTRUCTURE: A CASE OF ADDIS ABABA CITY STREETS AND UTILITY ASSETS**” is my original work that did not be presented to other University by any other person. All sources of materials used in this thesis have been duly acknowledged.

Name: **Fufa Lencho**

Signature: _____

Place: Addis Ababa University,
School of Graduate Studies,
Institute of Technology
School of Civil and Environmental Engineering

Date: June, 2024

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Acknowledgements

My deepest gratitude goes to my advisor Dr. Robeam Solomon, for his valuable advice, correction and support with complete humbleness and patient to all my requests for his help and advices during those challenging conditions of my researching period. Therefore, I heart fully would like to say thank you!

I would also like to thank all persons (individuals and institutions) who helped me in different ways since the starting or enrolment to ending of the courses and research journey, contributing their best to the success of my work. These include Ethiopian Roads Authority (ERA) who sponsored me financially and Addis Ababa University particularly; Institute of Technology (AAiT) who cooperated to grant me the opportunity of joining it for post graduate courses of Construction Technology and management stream and complete this research. I would also like to extend my gratitude to workers of the university who contributed to my work.

I cannot also wordlessly over pass without thanking the persons, again institutions and their personnel who heart fully cooperated with me in providing me with information and/or data important to realize this thesis. They include : AACAUBGD, AACRA, AAWSA, EEU, ETC whose name were written fully in acronym section, and their personnel who were direct participant in my work responding to the questions of the research presented in interview or questionnaire form.

At last but not least, I would like to thank my family who sacrificed their time and resources as well as other people who supported and encouraged me during undertaking of this thesis.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

ABSTRACT

Frequent excavation to existing city infrastructure (FEECI) imposes an adverse health and safety, aesthetic and economic in general, sustainability impacts on individual and community of a given environment particularly, city and country at all. Despite its impacts on economic and/or sustainability issues and hence human welfare in cities around the globe in general and in Addis Ababa city in particular, FEECI was overlooked or neglected by researchers and almost all individuals and/or communities (i.e. instead of being considered as problem, rather it has been accepted just as a ‘normal’, ‘expected’ or ‘allowable’ and ‘unavoidable’ practices).

Therefore, being motivated by an overarching characteristics of city and its infrastructure, and hence with inquiry and curiosity for root causes and impacts of FEECI, the author investigated the root causes and subsequent impacts of the problem (FEECI), on city, exist infrastructure and community particularly, that of Addis Ababa (the capital city of Ethiopia which also further assumed as ‘capital city of Africa’). To achieve this main goal and specific objectives of the research, data were collected via field observation with photographs, videos, note taking; face-to face interview survey with experienced professionals of infrastructural companies as well as questionnaire survey which was used as supplementary tool.

The data were analyzed under the mixed research—combination of both quantitative and qualitative approach, using appropriate and corresponding analysis techniques for each category of data. Descriptive (frequency distribution, measurement of central tendency such as mean/average, mode, median) and inferential statistics (Spearman’s correlation coefficient) were used for analysis of quantitative data obtained via questionnaire survey. Qualitative data collected by face-to face interview, secondary documents and field observations were analyzed by techniques such as narration, thematic analysis (TA) and Content analysis (CA).

Findings from all used methods of the study were triangulated. Results of the study indicated that intentional and unintentional human (infrastructure stakeholders) actions are root causes of FEECI in Addis Ababa city which in turn impose economic and sustainability impacts in terms of: repairing cost, operational cost, societal (health & safety/convenience) and environmental and/or aesthetics (ROSE) impacts on the city and users. These root causes were manifested by 20 indicators whose relative importance (RI) was found ranging from 0.86 to 0.59. ‘Poor/inappropriate infrastructure construction/ installation methods/ techniques’, ‘Absence/inapplicability of reliable specifications, standards, guidelines and legal frames for infrastructural related works and Management’ and ‘Overload/miss-utilization of infrastructures beyond their design capacity or their purpose’ were identified as the most important factors manifesting the root causes of FEECI. Empirical equation & regression model used to estimate impacts were also developed. Finally, the researcher has drawn conclusion and forwarded recommendations to concerning bodies based on the results of the research.

Keywords: City infrastructure, frequent excavations, root causes & impacts of frequent excavations

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Acronyms/List of Abbreviations

AACAUBGDB	Addis Ababa City Administration Urban Beautification & Green Development Bureau
AACRA	Addis Ababa City Road Authority
AAiT	Addis Ababa Institute of Technology
AAWSA	Addis Ababa Water and Sewerage Authority
APWA	American Public Works Association
AU	African Union
CCTV	Closed-circuit television
ESS	Ecosystem services
EMC	Electromagnetic conductivity
FEECI	Frequent excavations to existing city infrastructure
GDP	Gross Domestic Products
GI	Green Infrastructure
GIS	Geographic information systems
GNI	Gross national income
GPR	Ground Penetrating Radar
MTU	Mapping the underworld/space
MUT	Multi-utility Tunnel
NASTT	North American Society of Trenchless Technology
NJUG	National Joint Utilities Group
OSHA	Occupational Safety and Health Administration
ROW	Right of Way
SDI	Spatial data infrastructure
SSET	Scanner and evaluation technology
SUE	Surface utility Engineering
TT	Trenchless Technology
UNECA	United Nations Economic Commission for Africa
UUS	Urban Underground Space
WESP	World Economic Situation and Prospects

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

LIST OF TABLES

Table 2.1: Special projects to be built over identified land in the city structure plan

Table 2.2: Addis Ababa Infrastructure works stakeholders and their responsibilities

Table 2.3: Group of victims & impacts due to street reworks or frequent excavations in city

Table 3.1: Summary of sampling and data collection methods

Table 4.1: Codes and categories of interview data of corresponding respondents

Table 4.2: Rank or attribution of infrastructural companies to frequent excavation in the city

Table 4. 3: Construction /repairing costs of frequently failed and/or excavated street elements

Table 4.4: General information of respondents of questionnaire survey

Table 4.5: Responses and corresponding number of respondents to impacts investigation questions

Table 4.6: Analysis summary of responses to questions 3, 4, 5, 6 and 7 of questionnaire

Table 4.7: Analysis summary for response to question 8 of questionnaire for descriptive part

Table 4.8: Reliability test by Crombach's alpha coefficient

Table 4.9: Interpretation of ranges of values for Crombach's alpha coefficient

Table 4.10: Analysis summary for responses to question 8 of questionnaire for inferential part

Table 4.11: Relative importance (RI) of items indicating human actions as root causes of FEECI

Table 4.12: Economic (Monetized infrastructure repair) impacts of FEECI in Addis Ababa City

Table 4.13: Collected rework/repair costs as compensation for different excavation to road elements in 2015 E.C owing AACRA

Table 4.14: Annual (2015 E.C fiscal year) budget plan of AACRA for infrastructure maintenance costs

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

LIST OF FIGURES

- Fig. 2.1: Feature of early (1900 to 1909) Addis Ababa's säfär /clustered layout --'Taitu's Plan' (Source: Tufa, 2008)
- Figure 2.2: Structure/master plan of A/A city/general concept plan & detail of main city center redevelopment (AACPPPO, 2017)
- Fig. 2.3: Criterion of opening in earth to be called trench and Parts of trench (HMTRI, 2000) on (<https://tools.niehs.nih.gov/wetp/public/Course...>)
- Fig.2.4: Trenchless technologies (Jung and Sinha, 2007)
- Fig.2.5: Different types of MUT construction (a) & NJUG standards for utility installation in the UK (b)
- Figure 2.6: General conceptual framework of the study (by author)
- Fig. 2.7: Detail schematic description /flow diagram of the study (by author)
- Fig.2.8: Specific conceptual framework of the research (by author)
- Fig. 3.1: Map of entire Addis Ababa (with the 11 sub-cities as study area) source: Ethio-GIS-2022
- Fig.3.2: Sampling Process Steps and Sampling Techniques (Taherdoost, 2016)
- Fig.4.1: Observed excavations within Addis Ababa city located on Google Earth (by author on 28/8/2023)
- Fig.4.2: Repeated trench excavations to walkways of Adwa street (Captured by author from 28/6/2023 onward)
- Fig.4.3: Excavation of entire road & walkways at "Labu" (Captured by author)
- Fig.4.4: Trench excavation to walkway near DBE head quarter (Captured by author on 12/8/2023)
- Fig .4.5 Cutting /excavating asphalt road in front of AAUCNCS (Captured by author 3/9/2023)
- Fig. 4.6: Road damaged due to poorly constructed manhole (Captured by author on 2/11/2023)
- Fig.4.7:Trench & mass excavation to street near head quarter of CBE (captured by author from 07/06/2022 onward)
- Fig.4.8: Trench Excavation to walkway of 'Churchill Avenue' (captured by author on 9/6/2022 & 21/9/2022)
- Fig. 4.9: Trench excavation to right lane roadway of "Serra Leon Street" (captured by author)
- Fig. 4.10: Manhole repairing & excavation to "Serra Leon Street" left lane (captured by author)
- Fig 4.11: Excavation and reworks of damaged road elements at "Adey Ababa" (captured by author on 15/12/2022)
- Fig .4.12 Education Status, Level at job position and Experience in Year of respondents
- Fig. 4.13: Number of respondents to each options of impact investigation question 1
- Fig. 4.14: Number of respondents to each options of impact investigation question 2
- Fig.4.15: Alternative responses to question 3 and % ge of respondents
- Figure 4.16: Impact of frequent excavations on safety/ convenience of users (captured by author)
- Fig.4.17: Rough, dusty and muddy surface of asphalt road due to earth work (captured by author)
- Fig.4.18: Indirect economic impacts of repeated excavations to existing city infrastructure (captured by author on 25/9/2023)
- Fig.4.19: Poor culture of community /misusing of infrastructure in Addis Ababa (captured by author)
- Figure 4.20: Excel Add-ins regression analysis results of frequent excavations to existing infrastructure of Addis Ababa city

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

TABLE OF CONTENT

ACKNOWLEDGEMENTS.....	i
ABSTRACT.....	ii
ACRONYMS/LIST OF ABBREVIATIONS.....	iii
LIST OF TABLES.....	iv
LIST OF FIGURES.....	v
CHAPTER ONE: INTRODUCTION.....	1
1.1 General.....	1
1.2 Background of the Study.....	3
1.3 Statement of the Problem.....	6
1.4 Objectives of the Study.....	7
1.4.1 General objective of the Study.....	7
1.4.2. Specific objectives of the study.....	7
1.4.3 Research Questions.....	7
1.5 Significance of the Study.....	8
1.6 Scope of the research.....	8
1.7 Limitation of the research.....	9
1.8 Research organization/structure.....	9
CHAPTER TWO: LITERATURE REVIEW.....	11
2.1 Introduction.....	11
2.1.1 Definition of relevant terminologies and description of related Concepts.....	11
2.2 Definition, category and procedures/process of excavation.....	22
2.2.1 Definition of excavation.....	22
2.2.2 Types/category of excavations.....	23
2.2.3 Procedures/Process for Infrastructural Works of Addis Ababa city.....	24
2.3 Frequent Excavation to Existing City Infrastructure (FEECI).....	26
2.4 Impacts of frequent excavations to existing city infrastructures.....	28
2.4.1 Impact on health and safety/convenience.....	29
2.4.2 Impact on aesthetics of the living environment/city.....	31
2.4.3 Impacts on Economy.....	33
2.5 Mechanisms of excavation impacts Estimation.....	37

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

2.6 Causes of frequent excavations to existing city infrastructures	38
2.6.1 Natural and/or Environmental actions	40
2.6.2 Intentional and unintentional human actions as root causes of FEECI.....	41
2.6.3 Intermediate Causes	50
2.6.4 Immediate Causes	50
2.6.5 Summary and gaps of previous literatures on the problem understudy	51
2.7 Conceptual framework of the study.....	53
2.7.1 General Conceptual framework summarized from previous literature	53
2.5.2 Specific Conceptual framework of the research	57
CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY.....	58
3.1 Research design and approach.....	58
3.1.1 Research Type.....	58
3.1.2 Description of Research Area.....	58
3.2 Research Methodology.....	59
3.2.1 Sampling and sample size	59
3.2.2 Data sources and collection Methods.....	63
3.3 Data Analysis techniques and tools.....	65
3.3.1 Qualitative analysis	65
3.3.2 Quantitative analysis	65
CHAPTER FOUR: DATA ANALYSIS AND RESULT DISCUSSION.....	67
4.1 Introduction.....	67
4.2 Qualitative analysis.....	67
4.2.1 Analysis of data obtained interviewing respondent from AACaubGDB	71
4.2.2 Analysis of data obtained interviewing respondents from AACRA	73
4.2.3 Analysis of data obtained interviewing respondents from AAWSA	74
4.2.4 Analysis of data obtained interviewing respondents from EEU	76
4.2.5 Analysis of data obtained interviewing respondent from ETC	77
4.3 Analysis of data collected by field observations.....	81
4.4 Case studies of some observed frequent excavation events.....	92
4.5 Quantitative Analysis: Analysis of questionnaire survey data.....	104
4.5.1 Rate of Response.....	104
4.5.2 Descriptive Analysis	105

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

4.5.3 Inferential Analysis	128
4.6 Discussion & interpretation of results with respect to objectives of the research.....	134
4.6.1 Impacts of frequent excavations on existing infrastructures (FEECI) of Addis Ababa city..	134
4.6.2 Root causes of frequent excavations to existing infrastructure of Addis Ababa city.....	139
4.6.3 Developing/Modifying estimation mechanism for impacts of FEECI.....	142
4.6.4 Validation for Imperial equation of FEECI impacts/cost estimation.....	145
4.7 Guidelines to avoid/minimize frequent excavations/infrastructural reworks.....	147
4.7.1 Suggestions/guidelines input/ from AACAUBGDB respondent	148
4.7.2 Suggestions/guidelines input/ from AACRA respondents.....	148
4.7.3 Suggestions/guidelines input/ from AAWSA respondents	149
4.7.4 Suggestions/guidelines input from EEU respondents	149
4.7.5 Suggestions/guidelines input from ETC respondent.....	149
4.7.6 Summarized or augmented respondents' suggestions as basic input for common guidelines .	150
4.8 Findings of the research.....	151
4.8.1. Impacts of FEECI in Addis Ababa.....	151
4.8.2 Root Causes of FEECI in Addis Ababa	152
4.8.3 Modification/redevelopment of impact estimation mechanism in consideration of FEECI...	153
4.8.4 Development/provision of foundational material for common guidelines of infrastructure...	153
4.8.5 New findings of the research	153
CHAPTER FIVE: CONCLUSION AND RECOMMENDATION.....	155
5.1 CONCLUSION.....	155
5.2 RECOMMENDATIONS.....	157
5.3 Proposal for future research not filled gap.....	158
REFERENCES.....	159
APPENDICES.....	169

CHAPTER ONE: INTRODUCTION

1.1 General

Globally accepted facts and experiences indicate that lives, including, human beings could survive sustainably on the ‘most suitably livable planet’— the earth up to date, though other may be discovered in the future. To keep up such perpetuation and sustainability, we human beings always try to realize the necessary things known as ‘Maslow’s hierarchy of needs’—from ‘basic needs’ through ‘self-actualization’ even ‘beyond self-actualization’ (Maslow, 1971; Greene and Burke, 2007). These may cover involvements of human in several (social, political, economic, intellectual and spiritual) activities among many other aspects, whose some of manifestations include but not limited to the following:

1. The need for economic growth and/or development is why governments strategically plan to invest on infrastructure development(Chitkara,2000 as cited by Assefa,2008);
2. Undertaking effective and efficient spiritual, intellectual social, political and *economic activities* and hence being, healthy productive and wealthy ;
3. Owning efficient & effective infrastructures (“hard & soft”— according to (Knaap and Talen, 2003 cited in Yirsaw,2012 & Gebregziabher, 2014) with long service life and other inputs;
4. Application of instinctive & acquired human knowledge/experience, skills, science, technology & engineering principles particularly, civil engineering to infrastructural aspects;
5. Knowing and managing natural phenomena, human actions(Using principles, codes/standards, rules/regulations for undertaking spiritual, intellectual/technical, social, political and economic activities and cultural / behavioral practices) towards or against environment in this case, city and its infrastructures.

In the way of putting efforts for enhancement of human welfare or well-being of citizen, community of a given environment /habitation (urban/city, sub-urban or rural) or nation, the above listed issues can be interrelated in different ways either linearly or nonlinearly, particularly in this list, from bottom to top. Environment is a package of these and may be influenced for good or for evil. Particularly, city and its infrastructure may be influenced positively or negatively which in turns also affect human wellbeing in the same way.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

This new research was conducted within the conceptual framework that encompasses: (1) comprehensive or overarching importance of city and its infrastructure which is analogous to human live and /or health as well as healthy functioning of body organs; (2) the relationship and impacts of excavations with city and its infrastructure, mainly root causes and subsequent impacts of frequent excavations or rework to the existing city infrastructure.

Excavation is one of the primaries and an inevitable activity of construction and/or civil engineering works—infrastructure. Though it is important to construct and/or repair infrastructures for enhancement of human welfare, it also imposes different impacts (Metje et al., 2015). It can be understood that, intensity of excavation impacts in terms of type and magnitude increases with frequency of undertaking excavation especially, to the existing city infrastructure. To this end, some authors (Hunt and Rogers, 2006; Luo et al., 2019) expressed repeated or frequent excavations as “wastage of money”.

As mentioned earlier, human wellbeing in general and specially that of living and working in city can be affected by infrastructural rework and/or frequent excavations to existing city infrastructure (FEECI). This is because it inevitably touches health and safety, aesthetics, economic or sustainability aspects of individuals and/or community of a particular environment. Therefore, root causes of FEECI need to be scientifically investigated in a way of avoiding or minimizing the subsequent adverse impacts.

As also mentioned earlier, not only frequent excavation, even the planned and rarely undertaken excavation itself cannot to be undertaken without imposing impact. This is due to almost all of infrastructures are constructed or installed partially or fully on/in the earth to different depth of the ground and/or sub-surface as well as utilities are interdependent and hence excavation is not avoidable but can be undertaken to the possible minimum repetition or frequency. Thus, from this argument, one can intuitively imagine that how much larger the impacts of frequent excavations to the existing infrastructures of city could be.

Having these facts in mind, this research focuses on investigating the root causes of frequent excavations or ‘reworks’ of existing city infrastructure and their subsequent impacts on an environment particularly, city and its existing infrastructure as well as stakeholders.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

A number of authors (Metje et al., 2015; Makana et al., 2016; Jung and Sinha,2007; Pilvar, 2015; Yirsaw, 2012; Gebregziabher, 2014; Sahle, 2019;Luo et al., 2019; Hunt and Rogers, 2006; Moran et al., 2017; Love et al., n.d; Love et al., 2013, Love et al., 2019; Al-Bayati and Panzer, 2020;Kogali and Mohamed,1999;) have conducted and published their studies around this problem area (i.e. impacts or costs of damages during excavation and causes of strikes). Several scholars studied impacts of infrastructural works and or excavation, in terms of ‘social’, ‘economic’ and ‘environmental’ in general.

However, almost all of them did not thoroughly considered the root causes & true impacts of frequent excavations to existing city infrastructure. The main gap is that, they overlooked ‘frequent excavations to existing city infrastructure’ thus did not consider magnitude of the impacts as the result of repetition as well as did not explicitly identify the root causes. This new research was necessitated to fill such gap.

1.2 Background of the Study

As mentioned earlier, city in general is dependent on its infrastructures and important for not only residential purpose, but also for economic activities, growth and development as it is ‘power house of economy. Infrastructure in general and city infrastructure particularly, is ‘foundational or backbone’ of investment and /or one’s overall economy (Kumar, 2022). Despite of this, excavations to existing infrastructure of city have been imposing impacts in different aspects.

Moreover, FECCI has been observed globally but, overlooked or ignored by almost all of the infrastructural stakeholders and scholars in spite of such multifaceted impacts whose magnitude is expected to be more than that of the planed and regular excavations—not repeated. Only few scholars were even used the phrase ‘repeated excavation’ or ‘frequent excavations’.

For instance, though they did not distinguish the particular category of environments (urban/city, sub-urban or rural) where the excavations undertaken, some authors (CGA 2019b; McMahon et al. 2006 as cited in Al-Bayati and Panzer, (2020)) implicitly revealed reporting that about 28 million and 1.5million excavations to buried utilities took place annually in USA and UK respectively which implies the presence of frequent or repeated excavations.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Addis Ababa was established ‘organically or spontaneously’ -- without plan, at the center of the country (i.e. at the current Oromia regional state) in 1886 (Wubneh, 2013). Since then, it has been capital city of Ethiopia and center for several national and international commercial, social and political/diplomat institutions (AACPPO, 2017; Erena et al., 2017).

Beside this, Addis Ababa historically, has a proud for reputation of being city of not colonized country among African countries (World Fact Book, 2016), thus expected to be aesthetically beautiful & attractive for diplomats, conferences , tourism and livable (Hunt et al, 2016) for its dwellers and foreigners. Therefore, it needs to meet the modern and/or contemporary principles of city standards/requirements (‘*resilient city*’, ‘*tomorrow city*’ and ‘*smart city*’. Furthermore, it has been seen economically important to the country. UN-Habitat (2017) as cited in Weldeghebrael (2021) for instance, described Addis Ababa as the ‘economic powerhouse’ of Ethiopia generating 29% of the country’s urban GDP—Gross Domestic Products and 20% of national urban employment.

Foster and Morella (2010) also argued that population and economic activity particularly, agriculture are concentrated at central part of the country—Ethiopia. According to them, that is why urban areas particularly, Addis Ababa has been expected to be center where infrastructure development started and then extended towards surroundings where such dominant economic activity is agriculture. As also stated earlier, to realize such requirements infrastructure, particularly city infrastructure is vital and backbone.

In spite of this (historical, political and economic role of the city), some of the studies conducted in Ethiopia(Yirsaw, 2012; Gebregziabher, 2014; Yonas, 2014; Sahle, 2019) argued that there was no effective and efficient infrastructural services especially utility service provision in Ethiopian cities in general.

According to Gebregziabher (2014), services especially utility service provision in Addis Ababa is not efficient. From their arguments it can be noted that, had its infrastructure been efficient, effective and long-lived performing, the figure mentioned earlier (29% and 20% contribution of the city to GDP and employment respectively) could be greater. This is because the contribution of the city to the GDP is partly but mainly dependent on its existing long living and/or well-performing infrastructures among other factors.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Experiences from observation also indicate that there are early and frequent failure (damage, deterioration and obsolescence) and hence the need for frequent repairing and/or reconstructing. This in turns leads to frequent (Luo et al., 2019; Hunt and Rogers, 2006) and arbitrary (Jung and Sinha, 2007; Pilvar, 2015) excavations which also called as ‘ground disturbance’ by Info-Excavation guideline (2020) to existing city infrastructure or vice versa. Such problematic activities—repeated excavations has been experienced in Addis Ababa city being occurred here and there, whose root causes and true impacts need to be investigated scientifically.

Though it is not the case of Addis Ababa city, Sahle (2019) tried to identify ‘causes of frequent cutting road pavement’ and repetitive damage or loss of services in Ethiopian city particularly, that of Mekelle. However, the study did not thoroughly identify the root causes of such frequent and arbitrary excavations to the existing streets and utility assets yet.

Lack of integration among infrastructural stakeholders’ was identified by the authors of previous researches regarding conditions of several Ethiopian cities’ infrastructure and services as root cause for the inefficient and ineffective utility service provision. Even if it could be also one of the root causes of frequent excavations to the existing city infrastructure, the author of this new research belief that it is not the only root cause and thus, inspired to further investigate the other ‘concealed’ root causes and impacts of FEECI.

Therefore, the general economic and/or sustainability impacts of FEECI were studied in this new thesis in terms of: frequent infrastructure repair/rework cost, subsequent operational costs, Societal (health & safety/convenience impacts that can be said ‘social’, impacts on aesthetics of city —‘environmental’. Regression model for estimation of such costs or impacts of frequent excavations in terms of location/spatial and/or time of occurrence within Addis Ababa city was developed and validated by the collected data of infrastructure repairing costs.

Furthermore, the root causes of FEECI particularly, that of Addis Ababa city were investigated in this new research in the way to avoid and/or minimize the subsequent impacts to the possible extent and there by enhance performance of the city and its infrastructure.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

1.3 Statement of the Problem

Studies and observational results revealed that in spite of the vital role and holistic importance of cities and their infrastructure, there had been early and frequent failure of city infrastructure (street, utilities and green infrastructure etc.). This in turn led to undertake excavation especially, frequent excavations to existing city infrastructure (FEECI) to repair or vice versa.

On the other hand, *earth work*, particularly excavation and/or open cut among construction and/or civil engineering works, are important and inevitable. However, excavations (both the regularly planned and repeated arbitrarily) undertaken within the city street imposes several impacts. Especially, the frequent one may result in to direct & indirect large scale negative impacts on infrastructure and/or utility companies, business firms, users, city or country in general. Such problem (frequent excavations to existing infrastructure), has been commonly observed globally and also in Addis Ababa city. The rough and irregular appearance of walkways and roadways of the city as well as the active excavations observed being undertaken here and there in the city evidently indicate existence of the problem.

According to some previous literatures early and frequent failures (damage, deterioration and obsolescence) of city infrastructure may happen due to factors such as environmental conditions and/or natural forces, human actions or combination of the two in general. Once infrastructure failed, undertaking of excavation to repair/upgrade parts or whole of facilities is inevitable. From this argument though it seems the causes of excavations are known, the root causes of frequent failure and hence frequent excavations of existing city infrastructure were not explicitly and robustly investigated yet both in international and national cities including Addis Ababa.

Except few authors who tried to highlight it (Sahle, 2019; Luo et al., 2019; Hunt and Rogers, 2006), most of previous literatures overlooked impacts of FEECI, the contribution of frequency to magnitude of the impacts and their root cause(s). However, if this problem is not solved, health & safety of society (productivity), aesthetics & operations of the city thus, economy of the city or the country at all, may be negatively affected and the problem remains vicious circle. To fill such gap, this research aimed at investigating root cause(s) of FEECI & subsequent impacts (in terms of repairing, operational, societal (health & safety/convenience), environmental and/or aesthetics costs, generally on economy and/or sustainability).

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

1.4 Objectives of the Study

1.4.1 General objective of the Study

This research aims at investigating root *causes* and *impacts* of *frequent excavations* to existing city infrastructures of Addis Ababa in such a way of avoiding or minimizing those causes and impacts, so as to improve performance of infrastructure & the city.

1.4.2. Specific objectives of the study

- ❖ To assess economic/sustainability impacts of frequent excavations to existing infrastructure of Addis Ababa city
- ❖ To identify root causes of frequent excavations relevant to existing infrastructure of Addis Ababa city
- ❖ To develop empirical equation with regression model for infrastructural rework impact/cost estimation
- ❖ To provide basic guidelines and/or reference material for infrastructural stakeholders for efficient services and further work on future gaps of related problems

1.4.3 Research Questions

1. What type of impacts imposed by frequent excavations on existing infrastructures of Addis Ababa city?
2. What are the attributions and/or rank of utility companies to such repetition of excavations?
3. Why excavations frequently undertaken to existing infrastructure (streets, greenery & utilities) of the city?
4. What are the manifesting factors for root causes of FEECI & their respective importance?
5. How can the existing excavation impacts estimation techniques be modified for enhanced computation and decision making?
6. Do frequencies of excavations and/or the causes contribute to magnitude of impacts?
7. How can and what shall stakeholders use to avoid and /or minimize root causes & impacts of FEECI?

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

1.5 Significance of the Study

This study is primarily significant as it fills the identified gap shading light on the ‘root causes and impacts of frequent excavations to existing city infrastructure’ which need more focus but overlooked. This study is significant as it may provide stakeholders (urban planners and/or designers, utility companies, users), policy makers and academicians with findings and scientific knowledge of the problem (root causes and impacts of frequent excavations to existing city infrastructure (streets, utilities and green infrastructures etc.) within the established conceptual framework for awareness and understanding of the phenomena to prevent it.

The findings and/or the research paper as the whole may also be used as a basic guideline or audit for infrastructural works during the efforts made to produce clear, complete and forecasted design, properly implement new infrastructure , renovate, upgrading and operate the existing city infrastructure. Furthermore, the study may also be used as supportive evidence to make decisions, undertake further research on unforeseen gaps of related problems of infrastructural issues. In general, it may help in improving the well, long life or sustainable performance of city and its existing infrastructure by avoiding or minimizing early and frequent failure of infrastructure and hence frequent repair/maintenance or upgrading of facilities that causes frequent excavations or vice versa to as much as practically possible extent.

1.6 Scope of the research

This study was limited to the investigation of root causes of FECCI related to intentional and unintentional actions of infrastructure stakeholders in planning, design, implementation, operation, handling and maintenance practices of infrastructure and subsequent overall economic and/or sustainability impacts (Repairing costs, operational costs, Societal (health & safety/convenience) and aesthetics and/or environmental impacts) of frequent excavations on existing city infrastructures of Addis Ababa city and its users.

Infrastructure can be categorized mainly as 'hard', 'soft' (those will be described later) and also sometimes ‘critical infrastructure’ as the third category. However, for purpose of this research, only the ‘hard city infrastructure’ that also farther limited to the street (roadways and sidewalks of asphalt and cobble stone paved main and/or local roads of the city, road side/middle greenery and

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

spatially and/or functionally interrelated utility infrastructure such as potable water lines, sewerage lines, telecommunications and electric power lines and assets of these utilities. Bridges and Light rail transport infrastructure were not included.

Except repairing costs of several excavation events and modifying or redeveloping of mechanism used for impact estimation by sample data of frequent repair costs for existing infrastructure in Addis Ababa city, quantification and/or holistic impact estimation or monetarily valuation of the losses related to operational costs, Societal(health & safety/convenience) and aesthetics and/or environmental impacts etc. were not included in this research as it is infeasible due to it will be beyond the scope of this study--the broadness needing further research related but with independent title thus it can be one of further research area.

1.7 Limitation of the research

Like any other researches, this research also has several limitations. One of the limitations is the inability of including all excavation over entire the city though it was intended as study area. Although the study area of this research was intended to cover the entire Addis Ababa city (the 11 sub-cities) uniformly or in similar way, due to time and financial constraints field observation and collection of excavation event data as well as selection of case study were made more focusing over the central area/zone of the city where, socio-economic and political activities and institutions are relatively more concentrated than other peripheral zones of the city. In addition to this, the small number of sample for participants of questionnaire survey due to availability is also the other limitation to generalize the results. Leaving full validation of the developed empirical equation of impacts estimation is another limitation that may be filled by further research. Further, using or inclusion of several references that are not very recent but are fact and science as well as still very relevant to the study, can be the other third limitations of this research.

1.8 Research organization/structure

This research was organized in a way that it addresses the problem understudy containing five chapters each of which discusses corresponding issues in sub-sections as follows:

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Chapter one: contained the introduction part of the research which consists of general, background of the study, statement of the problem, objectives of the study, research questions, significance of the study, scope of the research, limitation and organization/structure research.

Chapter two: is largest portion of this research which covered the review of previous literature related to the problem under study. In this chapter, the reviewed explicit and implicit literatures are appraised and cited under the themes organized as in the following: Introduction (definitions and descriptions of terminologies and concepts); Causes of frequent excavations to existing city infrastructures; Natural and/or Environmental actions; Intentional and/or unintentional human actions; Intermediate Causes; Immediate Causes; Summary and gaps of previous literatures; Conceptual Framework of the study to list the main ones.

Chapter three: discussed the design and methodology of the research. Data collection methods, tools, area of research and analysis methods were described in this chapter.

Chapter four: in this, data collected through field observations, face-to-face interview and questionnaire survey were analyzed, discussed and interpreted triangulating the results from all of the methods in a way of enhancing the validity of the research findings.

Chapter five: of the research contained conclusion and recommendations parts of the research. The research findings were summarized in this chapter. Suggestions on what to be done as solution for the problem was made based on the result of the analysis.

Reference: section of the research was situated at the pages after chapter five of the research. It is a section of the research under which all cited literatures were alphabetically listed and or referenced in this research following Harvard referencing style.

Appendices: included annexes of different data collection tools or formats, cover letters and other documents used in this research.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

2.1.1 Definition of relevant terminologies and description of related Concepts

Before directly delving into reviewing literatures relevant to the problem under study, it is necessary to define important words, phrases, and describe main concepts of the study. Thus, the following sub-sections will give definitions and describe concepts as well as importance of several terminologies such as: Economy/economic growth or development, Sustainability /sustainable development, City, Infrastructure & Construction/infrastructural works.

2.1.1.1 Economy and Economic development

Economy: “The word economy derived from the Greek term for household management ("oikonomia") and is still used in that context. An economy encompasses all of the activities related to the production, consumption, and trade of goods and services in an entity, whether the entity is a nation or a small town.” (<https://www.investopedia.com/terms/e/economy.asp#toc-what-is-an-economy>). This implies that, economy has direct and indirect relationship or interdependency with individual and/or community environment particularly, city and infrastructure.

Economy is also one of the main bases of ranking and/or categorizing countries in terms of level of development. According to World Economic Situation and Prospects—WESP (2014), the level of countries’ development is measured by their economy which also interpreted based on some criteria such as: gross domestic product (GDP), per capita gross national income (GNI)—which regarded human assets index and an economic vulnerability index, Fuel (coal, oil and natural gas) export/import status etc. of a country.

Accordingly, world countries were categorized in to three broad categories: (1) Developed economies, (2) Economies in transition and (3) Developing economies. There are also different sub –groups such as Group of Seven, G7 which include Canada, Japan, France, Germany, Italy, United Kingdom and United States.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

2.1.1.2 Sustainability and Sustainable development

Sustainability (development): was defined as “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. It is a contemporary worldwide agenda since its initiation in 1992 to the 20th anniversary (in 2012 at Rio de Janeiro of Brazil) of United Nations leader annual conference on the agenda “Environment and Development—the Earth Summit”— attempting to provide a new political attention (Hovde and Moser (2004); Sierra, 2011; Echendu et al., 2020).

Since then, it had got emphasis and involved in a considerable research topics of many researchers around the globe. In most of those researches, Social, Economic and Environmental objectives were considered as “the pillars of sustainability development goals” (Hojjati et al., 2016; Hunt and Rogers, 2005; Hunt and Rogers, 2014). Parkin and Sharma (1999) also defined sustainability as ‘maintenance of capital—social (people and their knowledge, cultural institutions and social structures), natural (the stock of environmentally provided assets such as soil, air, forest and water which produce a flow of useful goods and services for our common use but being depilated.) and human made (Infrastructure and artefacts)’ and they discussed those said ‘pillars’ in detail.

2.1.1.3 Definition and Importance of City

According to Marcotullio and Solecki (2013), definition of city has been controversial among different groups of related literatures reviewed by them. However, they summarized the result of their review of those literatures regarding the definition of city to be two: ‘city as an entity’ and ‘city as a quality.’ Accordingly, while the first category of perspective of defining ‘city as an entity’ relates the definition to dense settlement in a space which based on four ways: demographic, economic, administrative, and functional, whereas under the view of city as quality, tries to define city as situation and location where style and ways of living changed gradually to improved and challenged social life as opposed to rural.

For the purpose of this research, definition of the city that is based on the first view—‘city as entity is more appropriate and accepted. As such city can be defined as the location in which demographically concentrated, dense, heterogeneous and large sized (different in different

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

context) population live or administered within specific political jurisdiction territory where most of the economic activities are commerce and related than agricultural as opposed to village, town and/or country side in general.

City is not only the living environment but also ‘economic power house’ or ‘engine’ according to UN-Habita (2017) cited in Weldeghebrael (2021) and World Bank (2006) cited in Dagnachew (2011). That means, city contributes to the economic growth of country in terms of GDP as it hosts more different economic, social and political activities those generate revenue in general. As also mentioned in background section, according to UN-Habitat (2017) as cited in Weldeghebrael (2021) Addis Ababa was ‘economic powerhouse’ of Ethiopia generating 29% of the country’s urban GDP—Gross Domestic Products and 20% of national urban employment . On the other hand, cities themselves are dependent on infrastructure (AACPPO, 2017; Kumar, 2022) to be considered as city and to play the earlier mentioned roles. Furthermore, city and its infrastructure have also relationship with civil engineering works/infrastructure works particularly; construction activities such as ‘excavation’/ ‘trenching’ that will be discussed later.

2.1.1.4 Definition, Category and Importance of Infrastructure

❖ Definition of Infrastructure

Infrastructure was defined and categorized in literatures by many different authors (Alehashemi et al., 2017; Baldwin and Dixon, 2008 ; Kasper, 2015; Lay, 2013; Moteff and Parfomak, 2004 ; Nijkamp and Ubbels, 1999; <https://www.investopedia.com/terms/i/infrastructure.asp>).

Among others several sources (<https://www.investopedia.com/terms/i/infrastructure.asp>; William, 2009) revealed that the word ‘infrastructure’ was used for the first time in the late 1880s, being derived from two French, terms ‘*infra*’- meaning below and ‘*structure*’ meaning building. Thus, accordingly, ‘infrastructure’ can said to be the foundation upon which the structure of an economy is built. It has both ancient (Lay, 2013; <https://www.reliance-foundary.com/blog/category/hardscape>; <https://www.techtarget.com/searchnetworking/>) and modern (William, 2009; Williams, 2007; Edwards, 2003 as cited in Alehashemi et al., 2017) historical background.

❖ Category/Types of Infrastructure

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Infrastructure mainly categorized in to two: ‘hard infrastructure’ which related to constructed physical structures and ‘soft infrastructure’ that refers to human and social/community services (Gebregziabher, 2014; <https://www.investopedia.com/terms/i/infrastructure.asp>). According to these sources, while ‘hard infrastructure’ include sectors of infrastructures such as water, transport, energy and telecommunications whereas, human capital and social or community facilities such as education, health, law enforcement institutions, emergency services and other related are regarded as ‘soft infrastructure’. In addition to these two categories, some literatures also add other ‘critical infrastructure’ as the third category that consists of assets that are defined by a government as being essential to the functioning of a society and economy, such as facilities for shelter and heating, telecommunication, public health, agriculture, etc. Although these can be used in different environs (rural, sub-urban and urban or city), they mainly installed and used in a more dense and interdependently manner in urban or city than other environs. Sectoral categories of infrastructure include but not limited to:

Transport infrastructure: is one of the important infrastructure categories that play crucial economic role as they used to move people and goods from place to place. These include different modality such as land transport (vehicular, train, pedestrian and biking which are based on street—road/highway and tracks) water transport (ships, port and related), air transport (Sietchiping et al., 2012; Polyzos and Tsiotas, 2020; Emeasoba et al., 2013; Shiferaw et al., 2015; Worku, 2011).

Power and/or energy infrastructure: include systems that used from production to distribution of energy such as electric, wind, natural gas, steam power etc. Among others , electric power generation, transmission and distribution involves development of different infrastructure systems such as dam, transmission towers , lines, cables, posts etc. to call few(Ethiopian electric utility.gov.et), 2021; Shanko, 2002; Mengistu, 2017; Allerhand, 2020).

Water and Sanitation infrastructure: this consists drinking water, irrigation water, drainage water both storm and sewer (Ashley and Cashman, 2006; Lubbers, 2013; Alegre & Almeida, 2009; Arisz and Burrell, 2006) systems that are the vital one of this infrastructural sector.

Information and Communication Technology(ICT) infrastructure: broadband internet and telecommunication as well as CCTVcamera systems those discussed by several authors(Lovitske ,2018 cited in Echendu et al.,2021; Czernich et al.,2011;Bekele ;2018; Harday ,2018;

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Koutroumpis,2009; Waverman et al.,2005; Madden and Savage,1997) are also other crucial of city infrastructure under this category .

Green infrastructure: these include green spaces with amenities and median and/or roadside trees (Benedict and McMahon, 2002; Herslund et al., 2018; Seifu and Stellmacher, 2020; Kimengsi and Fogwe, 2017; AACPPO, 2017).Green infrastructure are also one category of urban/city infrastructure that has been gaining popularity nowadays than ever before. According to (AACPPO, 2017), green coverage of Addis Ababa city is 37% of its total area.

Housing: is also one of the infrastructure categories which can also be further categorized based on their function. Among other, residential house which also called as ‘shelter’ is one of human basic needs. Although many are strived in the past decade, demand and provision of housing in Addis Ababa city is unbalanced and hence still the most burning issue (AACPPO, 2017). This research did not include more details than this regarding housing as it is out of the scope of the study.

City/ urban infrastructure: There is no clear delineation of categorizing infrastructure as ‘city infrastructure’ and ‘rural infrastructure’ as some of infrastructures may commonly developed and used in both environs. However, experiences and literatures revealed that almost all of the above described (but not limited to) sectors and their corresponding categories are belong to urban and/or cities.

Although the composition depends on the economic and technological development level of the particular city, most of available related literatures often list components of urban or physical cities to be: under categories of sectors such as transport/energy, water supply and sanitation, Communication and Green infrastructure as mentioned earlier.

Street and utility assets in general, are the vital and most often interdependent components of city infrastructure. Street and utility assets are the concern of this new research as they are fundamental and back bone for the existence and functioning of city. The document—Addis Ababa city structure plan (AACPPO, 2017) states that, streets are main configuring elements of cities that determine mobility and circulation whose pattern on the other hand is dependent on the topography and the settlement patterns both of which are critical of Addis Ababa city. It

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

further argues that street should be developed for people/pedestrian than vehicular and to support other social facilities as well as local economic activities revealing that the existing one has drawback both in design and implementation. Accordingly, impossible or inconvenient crossing of lanes on foot, shortage of roundabout, junctions, neglected pedestrian lanes and/or sidewalks, patterns, density and less coverage which was known to be only 17% before several years when the document was prepared.

According to the tenth edition concise oxford dictionary, the term ‘utility’ comes from the Latin word ‘*utilitas*’ from ‘*utilis*’ meaning ‘*useful*’. Utility was generally defined by economic literatures as “a total satisfaction or benefit obtained from consuming a good or services”. Whether they are of municipal or private utilities according to Luo et al. (2019) include: water and sewage pipes, electrical and telecommunication cables, etc.

For the purpose of this new research however, street components such as roadway, sidewalks, and green infrastructures in general, spaces and assets included in the ROW and utility systems as well as assets such as potable water lines, drainage and sewer lines, power and communications were concerned as mentioned earlier.

❖ Importance of Infrastructure

Infrastructure has vital economic importance in general (Aschauer, 1990; Murray, 2019; Morgan et al., 2019; Arimah, 2017; Alehashemi et al., 2017). Other authors also revealed that the significance of infrastructures in economy based on the sectors category as mentioned earlier. Among these, Alehashemi et al., (2017) argued that cities are dependent on infrastructure and infrastructure is as important as sun, plants and air are important.

Therefore, infrastructure can be said a ‘connecting bridge’ between city, economy and/or citizens welfare. However, according to arguments of several authors (Murray, 2019; Morgan et al., 2019), infrastructure can also be metaphorically said ‘a double edged sword’ (i.e. it has both positive and negative impacts on economy and sustainability). In a more clear expression, this is to reveal the fact that, infrastructure can positively enhance the economic growth if available and effectively provide the expected services. On the other hand, damaged and/or failure states of infrastructure, especially that happen frequently, results in a direct (as they need a huge amount of resources for both developing new, upgrade, maintain and repair the existing one) or indirect

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

(loss of productivity and/or revenue generating business or income) economic losses or negative impacts.

On the other hand, infrastructure and its service is dependent on several factors (natural, man-made and combination of the two). It can be mainly affected by engineering particularly, civil engineering works as all of its activities pass through the project life cycles from conception to demolishing and disposal (Guo et al., 2010; Bonnal et al., 2002; PMI, 2017; Gibson et al., 2006) which is a long life time in which different stakeholders/humans involve. It is also vulnerable of other human actions (cultural/behavioral and political) attitudes and usage of existing infrastructure. That means in appropriate human actions on existing infrastructures at all stages and practices may also cause different negative impacts.

After all, such impacts appeal to the economic and/or sustainability issues. Regarding this, Shen et al. (2010) for instance, suggested that because they have significant impact on achievement of sustainable development, construction projects especially infrastructures have to be regarded with the sustainability agenda. This implies that, projects throughout their life cycle need to be effective contributor to one's country and world economy in order to achieve the global and contemporary agenda—'the sustainable development goal'.

2.1.1.5 Background of Addis Ababa city: master plan, infrastructure & Utility services

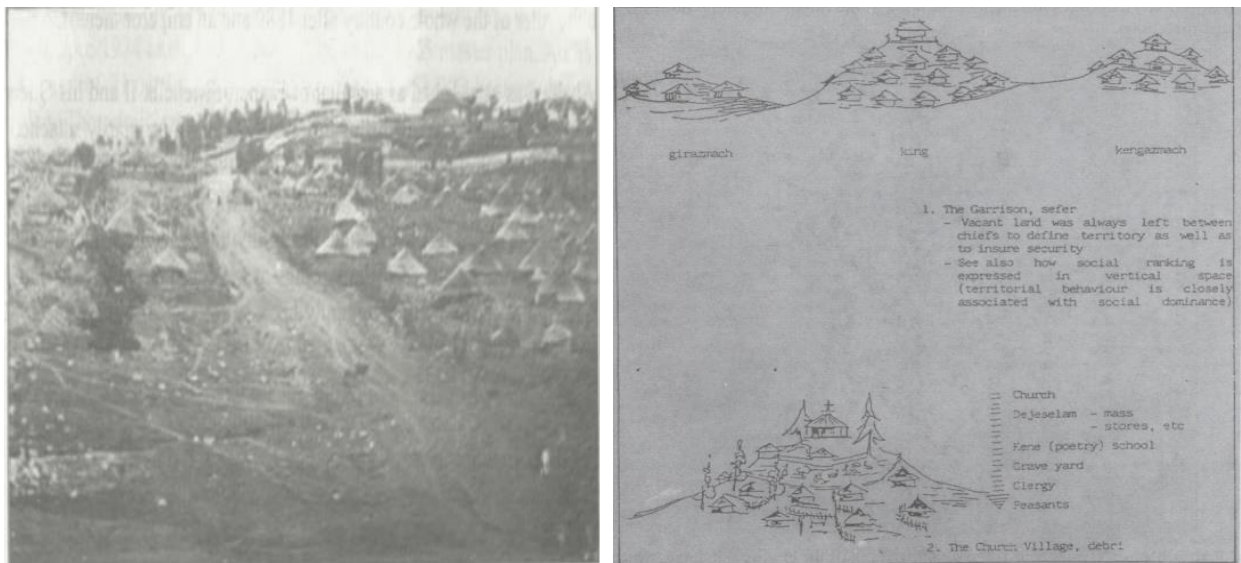
❖ Historical background and proposed consecutive master plans of Addis Ababa city

Literatures (AACPPO, 2017; <https://addisfortune.net/articles/addis-abebas-10th-master-plan-sees-13-districts/>) disclosed that since its establishment (1886), Addis Ababa had tried to have about ten master plans proposed and/or prepared consecutively but not properly implemented during different regimes. Those regimes and/or changes during which different infrastructures were introduced in the then town and/or the country according to AACPPO (2017) include:

The first period (1886-1935) was during which Addis Ababa was established spontaneously or organically—without plan on the basis of locality called 'Sefer' settlement by Empress Tuitu's traditional plan. The second change was the shortest period of Italian occupation (1935-1941) during which the first modern master plan of Addis Ababa was prepared by Italian. The 3rd period or 'Post-Italian period (1941-1974)' was the period during which 'urban life style' or

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

urbanism was emerged as the result of exposure to international experiences and expansion of modern education. The fourth change was (1974-1991) ‘Dergue regime which also called as socialist regime’—the period during which socialism was prevailed than privatization among many. During this period, private housing and land owning climax was limited. The fifth period ‘(1991 up to present)’ was also called as ‘Post Dergue’ and according to the document this period especially the past two decades were the time when many economic, population spatial growths of the city and infrastructure development particularly, large-scale roads and housings undertaken. The documents further revealed that, both of the last, ninth and tenth master plans of the city were developed during this period. While figure 2.1 indicates earlier Addis Ababa’s feature, figure 2.2 indicates the proposed land uses and redevelopment plan of the current tenth master or structure plan of Addis Ababa city.



(a) Feature of the early säfär, in 1900

(b) Traditional territories in vertical space: garrison säfär & a church with village development

Fig. 2.1: Feature of early (1900 to 1909) Addis Ababa’s säfär /clustered layout --‘Taitu’s Plan’ (Source: Tufa, 2008)

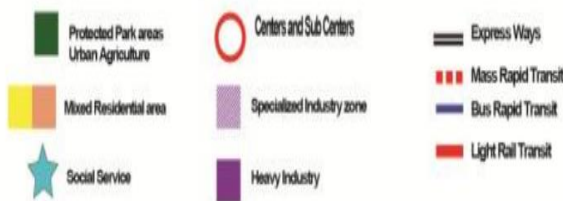
According to Addis fortune (<https://addisfortune.net/articles/addis-abebas-10th-master-plan-sees-13-districts/>), the ninth master plan — “Addis Ababa & Surrounding Oromia Special Zone Integrated master plan” was cancelled due to its controversialist emergence. Instead of it, other new master plan which accordingly called as ‘Addis Ababa’s 10th Master Plan’ was developed by the newly established entity called ‘Addis Ababa City Planning Project Office (AACPPO)’. It is this tenth master plan of the city which was also called as ‘Addis Ababa City Structure Plan’.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

The available document of this current plan, ‘Addis Ababa City Structure Plan Draft Final Summary Report (2017-2027) AACPPO’ was one of reviewed literatures for the purpose of this new research. The master plan document covered vast ideas of redeveloping of the city with main goal and specific objectives.



LEGEND



(a) ‘The Concept Plan’



(b) ‘Major redevelopment goals for the Main City Centre’

Figure 2.2: Structure/master plan of A/A city/general concept plan & detail of main city center redevelopment (AACPPO, 2017)

❖ Infrastructure and/or utility services of Addis Ababa city

Review of the document (AACPPO, 2017) indicates that though modified a little bit from time to time, the city infrastructure and/or utility services had been seen to be in sufficient and inefficient at all due organically establishment, topography (ups and downs) and many drawbacks of special growth of the city among different reasons. *“Even though there have been improvements in some areas, the state of service delivery in Addis Ababa is unsatisfactory;...Lack of efficient and*

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

reliable transport service, water and electricity, and waste management; adequate and affordable housing; and public spaces and parks are pressing challenges that need concerted efforts for redress.” (AACPPPO, 2017, p.17).

❖ Current Addis Ababa city development /redevelopment plan

As also discussed in the above section, Addis Ababa City Planning Project Office (AACPPPO) prepared the ‘structure plan’ or tenth master plan to develop and/or redevelop the old organically /spontaneously established city to make it ‘livable’ (AACPPPO, 2017). Other document (Future of Addis Ababa, 2021) which seems the derivative of the above cited document (Addis Ababa city structure plan draft), also further discussed the ‘future of Addis Ababa City’ and its infrastructural and/or utility services as well as function and profile most which are currently under construction. The document is the content of the structure plan draft up on which members from government and non-government officials including the current and former mayors of the city discussed. It also further disclosed that the strategic development framework was prepared to implement the master plan and overall administration of the city.

According to the documents, the structural plan and/or master plan as well as the ‘10 year development road map’ of the city were intended and prepared to be implemented with objectives of making Addis Ababa city: more competitive, livable, sustainable and inclusive city. They further discussed that these objective will be achieved through redevelopment of the city which was intended to be implemented with the ‘polycentric urban center organization land use principle’ which in turns guided by the ‘Transit oriented urban development (TOD)’ and ‘Development of nodes with reasonable distance (NODs)’. The derived document (Future of Addis Ababa ,2021),revealed that the specific objective of ‘making the city livable’ which costs US\$ 4,942 million estimated budget ,is to ‘improve access to infrastructure and basic services’ by improving urban mobility. Accordingly, several actions and detail actions such as: ‘Bus Network Optimization’, ‘Transform urban roads into safe and people centric roads’, ‘Improve Light Rail Transit (LRT) and prepare for priority mass transit corridors that are aligned with the city's mobility strategies, would be taken within short (one to two years) and medium to long (three to five or more years) strategic plan of the city.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Accordingly, considering the shortage, the land will be used effectively than ever before for the redevelopment of: ‘commerce’, ‘social services’, ‘municipal services’, ‘environmental preservation and/or protection’, ‘industrial zone(manufacturing and storage), ‘street networks and mixed residential use—high, medium and low density’. It further reveals that in addition to these, ‘special projects’ that are intended to attract foreign direct investment(FDI) and tourism will also be constructed on the land reserved separately for this purpose. Table 2.1 contained the lists, description and location where these special projects will be built.

Table 2.1: Special projects to be built over identified land in the city structure plan

Special Projects	Description	Location
Five star and above hotels (at least ten)	The primary objective is to increase the number of high quality hotels in the city and immediate surroundings. As much as possible and depending on the hotel character, central location is preferred	<ul style="list-style-type: none"> • Gottera, at the current cement factory site • Pushkin Square, at the current Adey Abeba Thread Factory site • Around Casainchis • Near Genet Hotel
High standard recreational facilities like golf course	Different recreational services are planned to enhance the Competitiveness of the city-region	<ul style="list-style-type: none"> • Koye Feche, south of Addis Ababa (next to the new site for housing development)
High standard shopping malls	The anticipated shopping malls are expected to be of high quality and their size should consider the different catchment	<ul style="list-style-type: none"> • La Gar--south of the train station • Lafto – Hana Mariam junction • Bole – current Millennium Hall • Meri- at trade centre • Torhailoch junction
Specialized/ general/referral hospital	The city should have at least two high level specialized and/or general hospitals.	<ul style="list-style-type: none"> • Around Africa Union and near CMC

Source: (AACPPPO, 2017)

These imply that there will be huge infrastructural and/or street works which involves more civil engineering works mainly, earth works (excavation, cart away, back fill and other related activities) than the currently being undertaken problematic frequent excavations.

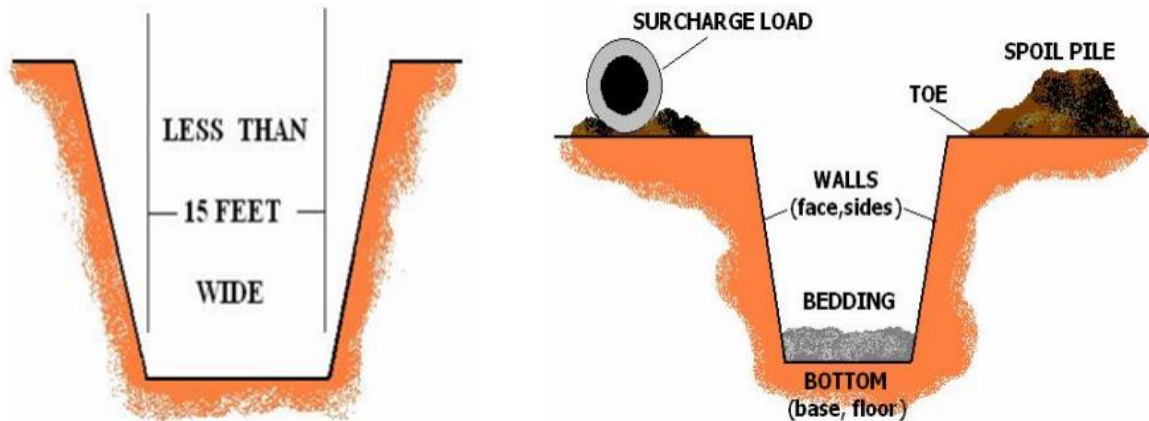
2.2 Definition, category and procedures/process of excavation

2.2.1 Definition of excavation

The tenth edition of Concise Oxford Dictionary defined excavation (1) as “Making (a hole or channel) by digging” accordingly, which mean “extracting (material) from the ground by digging” and (2) as “Carefully removing earth from (an area) in order to find buried remains”. It seems that the definition given by the dictionary were purpose based category of excavation in which the first definition is related to construction or infrastructural works and the second is related to archeological and related purpose. Although any type of excavation in the city matters, the most concern of this research is the first definition—construction or infrastructural work related excavation. In addition to the definition given by the dictionary, there are several definitions and types of excavations. For example, Occupational Safety and Health Administration—OSHA 2226-10R (2015) defined excavation as ‘any man-made cut, cavity, trench, or depression in the Earth’s surface formed by earth removal’ and trench as ‘a narrow excavation (in relation to its length) made below the surface of the ground. According to the document in general, the depth of a trench is greater than its width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m).

The document (HMTRI, 2000), also elaborated the definition of excavation and trenching given by OSHA. Accordingly, all trenches can be considered as excavations but not the reverse; again both are common being ‘openings in to the earth’ undertaken either for new construction or repair and whose consequent is dependent on the way as well as frequency it is undertaken. The document further described trench and illustrated below its parts as in the figure 2.1.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets



(a) Criterion of opening in earth to be called trench (b) Parts of trench

Fig. 2.3: Criterion of opening in earth to be called trench and Parts of trench (HMTRI, 2000) on (<https://tools.niehs.nih.gov/wetp/public/Course...>)

Commonly known shapes of the trench are listed in the document to be: Straight trench, Sloped trench, Benched trench and Bell-Bottom Pier Hole. Accordingly, these shapes are dependent on purpose of the trench such as: The Soil type in which the trench is excavated, Size of asset line to be laid in the trench, Presence of supporting systems, Set back and/or position of structures, utility assets or other properties and 'Location of the trench (roadway, open field, etc.) and Conduit loading requirements'.

Excavation was further defined and classified in almost a similar way to the above definitions also in some other sources such as <https://ronmeyerexcavating.com/types-of-excavation/> and <https://www.pinoybuilders.ph/basics-of-infrastructure-excavation2/>. Furthermore, types/categories of excavations were listed and described in these sources.

2.2.2 Types/category of excavations

Though the way they categorised or classified was somewhat similar, the type of excavations are a little bit different, there are several commonly listed and described types of excavations (based on the purpose/objective, material and environment of the excavation) in both the above cited sources. Roadway excavation; Rock excavation; Stripping excavation; Topsoil excavation and Underground/ Tunnelling / Shaft Excavation are some of their lists.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

The document available as ‘Guidelines for Excavation Work Done Near Our Underground Infrastructures’ (2020) called excavation as “ground disturbance work” and also listed a number of excavation types (most of which are common to the formerly listed) that accordingly may include, but not limited to: “Digging; Excavating; Trenching; Ditching; Tunnelling; Trenchless excavation/drilling/pile-driving; etc.”.

In general, regarding the definition, purpose, methods and procedures of excavation, the aforementioned ideas of the sources can be summarized in to common words. Thus, excavation can be defined as removal of materials digging by hand tools, equipment/machinery and explosive for: (1) construction of facilities and/or civil engineering works/infrastructures and /or (2) other undertakings related to science and land remediation (which is not the concern of this study).

Moreover, literatures revealed that, whatever the type, purpose and method of excavation it is, repeated/frequent excavations or, ground disturbances’ are not necessary in economic and/or ‘sustainability agenda’ point of view. This is because such repeated construction/infrastructure works particularly, earth work (Jung and Sinha, 2007) / that in general stated as ‘street works’ in Pilvar (2015) and as “rework” in Love et al. (n.d, 2013, 2019) imposes several types of impacts that will be discussed later. Although most types of the excavation may be undertaken in the same street work, ‘Digging’; ‘Excavating’; ‘Trenching’; ‘Ditching’ excavation types that were undertaken to road ways and walkways of the city were relevant to this new study.

2.2.3 Procedures/Process for Infrastructural Works of Addis Ababa city

Literatures (Gebreegzhr, 2014; Integrated urban infrastructure and services planning manual, 2006 as cited in Gebreegzhr, 2014) listed and described responsible and permitting bodies for infrastructural works (from excavation to reinstatement) of Addis Ababa city during the past decade. Accordingly, Addis Ababa City Road Authority (AACRA), the established ad-hoc committee and Addis Ababa Infrastructure and 36 Construction Authority (AAICA) who was responsible for permitting road cut/excavation, integrating infrastructure development and coordination of infrastructure institutions and supervision of the projects respectively. Moreover, the literature revealed that there has been several processes and procedures that were followed formerly by each stakeholders. The processes and procedures include:

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

1. Requisition of work (excavation/cut to pavement) permit from AAICA— mandatory requirements of utility companies/particular applicant
2. Acquisition of data and/or information of existing buried utility lines from all respective companies — requirements of utility companies/particular applicant/
3. Checking whether all requirements of the applicant(obtaining permit from AACRA & buried utilities from correspondent company) are fulfilled— mandate of AAICA

Currently the procedure/process of infrastructural works of Addis Ababa city is a little bit different from the above. Review of contract document between stakeholders of infrastructure works reveals that there are several procedures for infrastructural works (construction of new, expansion and/or upgrading and repairing of existing infrastructure of the city) and responsibilities of stakeholders. According to the document stakeholders, their responsibility or requirements and procedures/processes of infrastructural work are as follows:

- 1. Stakeholders and their responsibilities:-** the following table indicates the stakeholders and their responsibilities/mandates or requirements

Table 2.2: Addis Ababa Infrastructure works stakeholders and their responsibilities

No.	Stakeholders	Responsibility/mandate or requirements
1	Addis Ababa Construction Permit and Control Authority(AACPC)	Review submitted documents ,give work permit , coordinate stakeholders and monitor and supervises the work
2	Addis Ababa Traffic Management Authority(AATMA)	Perform the cooperative and/or coordination works in the vicinity of excavation in order the traffic flow is not disturbed
3	Infrastructure companies	Provide: Information, work request with relevant documents, perform the work scheduled by them and requested by the other companies in general
3.1	Addis Ababa Road (AACRA)	Make tight follow up and control to works being undertaken to street in order to ensure the work reinstated appropriately
3.2	Addis Ababa Water and sewer(AAWSA)	Request work permission submitting relevant document, complete work the work as per the schedule, provide information required
3.3	Ethiopian Electric Utility(EEU)	Request work permission submitting relevant document, complete work the work as per the schedule, provide information required
3.4	Ethio-Tele-Com(ETC)	Request work permission submitting relevant document, complete work the work as per the schedule, provide information required

Source: Summary of author on contract document (requirements) between infrastructure construction stakeholders

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

2. Procedures/process of infrastructure works and/or excavation to existing city infrastructure:

- i. First, work permit should be requested by the company who is going to undertake any infrastructural work through letter brought to AACPC with all relevant documents (design and schedule of the proposed work) attached to the requisition letter;
- ii. Next, review of documents and invitation of all concerning stake holders to review the document, make meeting, visit site, provide required information & assistance regarding location of buried utilities and sign contract and/or Memorandum of Understanding among themselves should be made through coordination role of AACPC,
- iii. Then, permission of the work is granted to the company with the responsibility and accountability of performing the work as per the requirements (timely, with no or minimum disturbance, paying for damaged utility if any etc.)
- iv. Assistance, monitoring and controlling of the work are given by all require stakeholders including AACPC until the work completed.

2.3 Frequent Excavation to Existing City Infrastructure (FEECI)

While the phrase ‘frequent excavation’ is rarely used and hence hardly found even by search engine of Google in literatures , it has been used equivalently or as synonym to phrases such as: ‘repeated excavation’(Hunt and Rogers,2006; Luo et al.,2019), ‘repeated work’(Mahlet Gebreegzhr,2014) ,‘rework’(Love n. d, 2013,2019), and ‘frequent opening of road’(Moran et al.,2017) etc. Despite of its worldwide happening and adverse impacts, it was overlooked or neglected by almost all of scholars those have been working on problems related to infrastructural issues as the lack of definition and use of the term in literatures evidently indicates.

Moreover, the term “Frequent excavation” is not only to refer to cutting, digging or trenching activities; rather, it was used in this research to mean every works from excavation, cutting in to whether paved or unpaved surface of the streets and or spaces, reinstating, compacting and cart away of the surplus material within city.

International and National FEECI events

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

When seen internationally, relatively many were written regarding repeated street works or infrastructural works of UK. For instance, one of the literatures states “The UK’s local road infrastructure is subject to *frequent openings* to maintain and invest in buried infrastructure”(Moran et al., 2017,p.115).It also further list the impacts of opening/cutting or excavating of road to be: reduction of road structural integrity, the need for additional traffic management due to congestion, environmental pollution. According to them, these further contribute in increased operational costs or ‘road use’ costs, negatively affected local business or loss of income generation of commercial firms, societal impacts, shorten useful life span of the road asset which in turns lead to un ‘planned’ or arbitrary maintenances.

“Repeated excavations of buried utilities cause road congestion and maintenance conflicts. Besides, the interference of buried utilities in limited underground spaces does not meet the requirement of sustainable urban underground development;...Repeated road excavation for utility maintenance considerably increases the maintenance costs, and is a common cause for road congestion. Furthermore, the buried utilities can be damaged by being directly exposed to underground environment (e.g. soil and humidity) or being accidentally hit by excavation equipment. Frequent excavation for different utilities is a waste of money especially if utilities under the same road are repaired at different times” (Luo et al., 2019, p.1). They also quoted other’s statement regarding frequent excavation, “Frequent excavation for different utilities is a waste of money especially if utilities under the same road are repaired at different times (Hunt and Rogers 2006 as cited in Luo et al., 2019, p.1).Although these authors advocating the importance of multi-utility tunnel (MUT) construction in china city, their article indirectly reveals that there was the frequent or repeated excavation to existing city infrastructure to maintain or repair existing and to construct new infrastructure to cope with increased demand of infrastructural services.

Love (n. d, 2013, 2019), also worked more on the causes and costs of ‘reworks’ in construction industry almost all over international cases. Although the term ‘rework’ is general and meaning ‘doing again’, it can be used as synonymy in this context as it indicate repetition and excavation is one of the main among civil engineering activities. Moreover the articles revealed that, such reworks or repeated works are deliberately ‘concealed’ by workers from being reported or exposed as they have additional consequences and from this it seems that is why researches

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

related to frequent or repeated excavation is not sufficiently available in the worlds' research data bases.

Nationally, only two authors (Gebreegzhbr, 2014; Sahle, 2019), merely used the terms related to 'frequent excavation' in Ethiopia. Both slightly revealed that there are repeated works or frequent pavement cut in Addis Ababa and Mekelle city respectively though their main focus were not the frequent excavations on existing city infrastructure.

2.4 Impacts of frequent excavations to existing city infrastructures

Several literatures (Leong, 2005; Santos et al., 2021) and others those cited above revealed the impacts of 'infrastructure works', particularly, excavation and/or trenching (but not thoroughly considered that of frequent excavations on existing city infrastructure—(one of the gaps to be filled). They also expressed the impacts in terms of cost as 'total or real cost which accordingly equals to the sum of direct costs, indirect costs and/or social costs'.

Among the previous researches regarding impacts of 'infrastructure works,' the one recently conducted in the state Rio de Janeiro of Brazil by Santos et al. (2021) was interesting. They have identified a number of impacts in their priority and/or importance order as follows:

Partial or total interdiction of vehicle traffic (considered as "traffic congestion" by other authors), Risks to the safety of road users and workers, Atmospheric pollution, Damage to the pavement, Noise pollution, Interruptions and changes in local pedestrian traffic, Damage to pre-existing networks, Damage to the local economy, Reduction in public space used by the population, Change in local landscape, Damage to the underground ecosystem, Low energy efficiency of the operation, Additional cleaning expenses and Reduction in tax collection.

They also identified 'the most important (accordingly rated to be 'higher than 4.5 from the *relative median* by the three categories of their respondents') several impacts among the above listed to be: 'Partial or total interdiction of vehicle traffic'; 'Atmospheric pollution'; 'Risks to the safety of road users and workers'; 'Noise pollution'; 'Damage to the pavement'; 'Interruptions and changes in local pedestrian traffic' and 'Damage to pre-existing networks'. The authors further revealed that two of these impacts ('Partial or total interdiction of vehicle traffic and risks

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

to the safety of road users and workers’) were rated as ‘extremely important’ by the entire group of respondents to their survey.

As also mentioned earlier, these impacts and others those reviewed in literatures (those categorized as ‘direct costs’, ‘indirect costs’, ‘social costs’, ‘environmental costs’ or collectively called as ‘true costs’ or ‘full costs’) were identified to be consequences of excavation though they were expressed in different ways . However, for the purpose of this new research (to fill the gap) the impacts will be presented in terms of several more general categories: ROSE—repair/infrastructural rework costs, operational costs, societal (health & safety/convenience impacts), environmental and/or aesthetic impacts (Khogali and Mohamed, 1999). These collectively contribute to economic impact and/or impacts related to ‘sustainable development’—the contemporary global agenda.

2.4.1 Impact on health and safety/convenience

The “*Safety first!*” slogan is commonly known and used now days in every discipline including in engineering though it is not fruit full yet as such. It is because all things required to lead life, be grow and developed will be necessary but come next to one’s being safe, healthy and /or alive. No one can be productive in economic activity, neither support his /her self, family nor contribute in country’s GDP, if not healthy, physically able and not alive; and easily move from place to place, rather will be burden to family and country. That is why health safety needs prior attention. In general health contributes to GDP hence economic growth (Suhrcke et al., 2006).

Although it is not the sole discipline where accidents happen, construction is one of the main areas of safety consideration. This is because most of the involved activities are prone to accidents and can cause health and safety problems (diseases, injury and death) to human and further accidental problems to other resources in the environment, unless properly managed (Metje et al., 2015). Among this activities, excavation particularly, repeated excavation to city streets, are one of the risky construction activity (Hunt and Rogers, 2014).

McCluskey et al. (1988) pointed out that engineering design should make sure the safety and quality requirement is achieved. Bernold (2003) tried to calculate the cost incurred following the damaged utility line particularly, gas pipe that clearly indicated how such accident (safety impact) has direct relationship with economic impact that will be discussed later.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Santos et al.(2021) as referred above, conducted the research around ‘Olympic Park’ where the intense infrastructure work(excavations and other activities) of ‘modernization and adaptation of the existing infrastructure’ for the ‘hosting of the Rio 2016 Olympic Games’ as their focused study area ‘to investigate the impacts of infrastructure works’. They identified fourteen impacts. Among the impacts identified by these authors, some of them include: (‘Risks to the safety of road users and workers’, ‘Atmospheric pollution’, and ‘Noise pollution’) can be included in the health and safety aspect category.

While ‘Atmospheric pollution’ and ‘Noise pollution’ can be considered as environmental impact at the same time, they can also be considered as ‘health impact’. Moreover, ‘Risks to the safety of road users and workers’ is the important impact both in their and this new research because it is basic for all as it concerns to the safety issue as discussed earlier in this section.

According to the authors (Santos et al., 2021), the infrastructure work on the public road and/or in city is characterized by ‘partial closure of the roads, the location, size, access to the construction site, open ditches and imperfect roads, sidewalks and cycle paths’ that result in to accidents (pedestrian fall/inconvenience in mobility especially to dis abled persons, work and traffic) that in turns resulted in to injury and/or death. Among the activities excavation (open, trenching and pits) are the most contributors to such health, safety and inconvenience impacts.

Other authors for instance, Metje et al. (2015) also analyzed the causes, impacts and/or costs of utility strikes in general but did not considered that of the frequent excavations (such as ‘more than 1.5 million holes in UK per year by utility companies’) that led to those strikes and subsequent impacts. They merely highlighted the causes of such frequent excavations to be “repairing and upgrading of buried infrastructures”.

Moreover, they summarized the safety and health impacts from HSE (2014) as cited by them. Accordingly, different impacts those reported were detected corresponding to the respective strike of utilities. For instance, Electrocute, Explosions, Flames and/or fires with Electric cables strike (which was estimated to cause about ‘12 deaths and 600 serious injuries every year’); Gas explosions, gas leakages, injuries due to inhalation of gas from damaged gas pipes; Flooding, environmental degradation due to sewage flooding, disease spread or contamination from sewage water entering in to other pipelines because of damaged water and sewer pipes.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

In addition, damage of telecom cables (highly expensive) results in to high cost of repairing though it has no direct health and safety impacts opposite to the literature that state the fiber optics are unsafe to eye. To this end the document, Guidelines for Excavation Work Done Near Our Underground Infrastructures (2020) says “Fibre-optic lines transmit light that may damage the retina permanently and are covered by a hard-metal jacket that may be sharp and very dangerous”. They also pointed out that the possible impacts (injuries when there is skin contact with volatile liquids and environmental damage due to leakage of petrochemicals and oils) as a result of failure of others pipelines.

However, these authors did not consider the inconvenience impacts due to disturbed roadways and walkways on users especially disabled, elders (Santos et al., 2021) persons and children as the excavated ground not only make difficult mobility but also can cause the accident of falling into the holes and/or trenches at their surroundings or else were in the excavated environments.

Here it is important to note the limitation of these authors and others in related literatures is that, they accepted the frequent excavations as normal or allowable activities (as Love, n.d revealed the way people perceive ‘rework’—‘concealing’ it and/or thinking it ‘as normally acceptable’) though the planned activity of street works are inevitable.

2.4.2 Impact on aesthetics of the living environment/city

Because *aesthetics* covers wide ranges of disciplines (‘art’, ‘philosophy’, ‘social science’ to ‘cultural history’), it has no single or unique meaning (Tribot et al., 2018). However, there are attempted definitions by several authors. For instance, according to Boersema (2012) cited by Tribot et al. (2018), aesthetics is “a branch of philosophy that questions the *beauty* in art and aesthetic valuation of artworks”.

Other authors (Shimamura and Palmer, 2012; Chatterjee, 2014; Ingold, 2000) cited there, also tried to define aesthetics with different perspectives and terminologies such as ‘transmitters—observed object/environment/landscape’, ‘receiver/—human’, ‘beauty’, ‘pleasure’, etc. but that revolve around a common central idea (the relationship between the observed object and / or environment and the observer). Although they focused on its artistic and/or philosophical point of view, their arguments imply that the aesthetics/beauty is not common to all, both at the same or

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

different time. On the other hand, Capdevila-Werning and Lehtinen (2021) advocated the “intergenerational aesthetics — a relatively new subspecialty academic field of philosophical aesthetics” which according to them focuses on ‘environmental and everyday aesthetics, opposed to the former authors.

Moreover, they discussed with aesthetics focusing on the human influence or human acts on environment in terms of sustainability. What these authors (Capdevila-Werning and Lehtinen, 2021) share commonly with the former regarding the aesthetics is that, it is dependent on the perception of individuals or community of the same and/or different generation—past, present and future and thus recommended that the perspectives of the future generation should be decided by neither the past nor the present generation.

Summarizing these definitions of aesthetics in to the central idea for the purpose of this new research, aesthetics can be defined as the *attractive and pleasant appearance of combined natural and man-made environment of human beings*. In engineering though aesthetics can be considered as the third aspect following safety and economy, it is important aspect especially in looks of cities and historical places where many inhabitant and visitors are most often concentrated. For city to be said beautiful and attractive environment, it should be clean (not dusty, muddy and rubbished) and green. This means the ‘environmental amenity’ or the beautifulness, pleasantness and attractiveness of a place and/or an environment especially city (Jim, 2003).

According to the author, road side trees which contributed to the aforementioned aesthetic value of city being appeared as a ‘landscape’ in addition to showing that the city is ‘livable’ and ‘sustainable’(Jim,2003;Hunt et al.2016). Such character and/or appearance has an aesthetic value as it contribute in productivity (as a result of improved life quality, being safe and healthy, creative of inhabitant) and income generation (due to attraction of tourism and related events) contributing in to economic growth and/or development of the city or a country at all.

This on the other hand, is highly dependent on the human actions or activities like the way they plant and preserve road side or street plants and green areas in general; undertake construction activities (Jim,2003) particularly excavation related to infrastructure. For instance, the author

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

pointed out that the trenching activity particularly, that inappropriately undertaken during installation and/or repairing of utilities damage such interesting street or road side trees of city.

Similarly, three(‘Reduction in public space used by the population’ , ‘Change in local landscape’ and ‘Damage to the underground ecosystem’) of the fourteen impacts of infrastructure work identified earlier by Santos et al.(2021) can also be considered as the one affecting the aesthetic value of city. Although the authors’ focuses were different, their discussions generally advocate a common thing — impacts of excavation to the existing city infrastructure. For instance, Jim (2003) discussed with the trenching practices within city more focusing on its impacts on road side trees of city whereas, Hunt et al. (2016) advocated the use of underground resources through implementation of urban underground space (UUS).

On the other hand, Santos et al. (2021) discussed with the impacts of infrastructure work in general .What makes their argument common is that, all suggested the use of alternative solutions and/or technologies such as UUS/MUT, TT, Micro tunneling etc. to avoid and/or minimize the devastating impacts of the traditional or open cut excavation within city.

2.4.3 Impacts on Economy

Here also it is important to recall the definition and concepts of some relevant terminologies, theories and/or principles related to ‘Economy’ and ‘Sustainability’ and/or ‘economic development’ and sustainable development’ that discussed earlier, before reviewing the literatures related to the main point of this section (economic impact of frequent excavation to existing city infrastructures).

Despite the focus and availability of researches regarding sustainability, the impact of frequent excavation on existing city infrastructure was ignored/overlooked by negligence and/or accepting it just as a normal activity (Love et al, n.d) evidently that is why there are only very limited number of authors who tried to consider even the impact of mandatory excavation, but not frequent excavations. Several authors such as Hojjati et al. (2016) and others conducted sustainable agenda based research relating human to natural environment with infrastructure.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Shen et al., (2010) suggested that because construction projects, especially infrastructures have significant impact on achievement of sustainable development, they have to be regarded with the sustainability agenda. That mean, projects throughout their life cycle need to be economical to one's, country and world economy in order to achieve the 'sustainable development goal'.

Economy, as also defined earlier, can in general be said 'the power' of an individual, community and country. Since it is a function of human capital and physical capital /infrastructure as stated by Aschauer (1990), economy can be positively or negatively affected by such input factors. Economy is highly dependent up on healthy, safe and hence productive human capital and efficient physical capital (existing infrastructures).

Frequently excavated and hence damaged infrastructure or vice versa particularly, existing city infrastructure (street, utilities and green spaces) cannot serve efficiently and positively influence economy. Rather, it negatively affect the economy by leading to the increased cost for maintenance and repair in addition to the loss of productivity and/or income (Hojjati et al., 2016) from it during maintenance and/or repairing period.

Hovde and Moser (2004) indicated the contemporary, an ever-increasing focus on the needs to determine durability and service life of materials, components, installations, structures and buildings particularly, concerning the two important aspects: Environmental issues and Economic issues.

According to them, economic issue concerns with the total value of the built environment on a national level and the value of each specific unit (buildings, structures, roads, bridges, quays, etc.) for the owners (government, private sector or individuals) and thus, the conditions of the built environment, the annual costs of management and maintenance and the life cycle costs are of major importance be it for the economy of a country, or maintaining competitiveness within an industry or corporation and they reasoned out that as this importance led to the initiation of the 'Sustainable Development'.

Few authors (Bernold, 2003; Khogali and Mohamed, 1999) revealed that the damage of infrastructure during excavation has an 'economic impact' on both private and public business but not gain emphasis by researchers.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

However, what should be noted is that the economic issue is key agenda that need more focus and priority as no one can realize ‘sustainability/Sustainable Development agenda’ if not be economical in all aspects. This is why all most all of our (human beings) living aspects on this planet, even on others! , have a direct and indirect relationship with economic influence on it. Evidently, that is also why literatures revealed that economy is one of the pillars of sustainable development among the others—Social and Environmental (Echendu et al.,2020) that indicate sustainable development is dependent on these ‘three pillars’, particularly and mainly on economy.

Several researchers on topics related to this problem including Rogers and Hunt (2006) in UK, argued for sustainable use and preferable use of one of the alternative technology to install utility infrastructure—Multi-Utility Tunnels (MUTs) relative to Trenchless Technology (TT) and traditional trenching such as open-cut excavation.

They further revealed the impacts/costs (true; real; direct and indirect) in terms of ‘pillars of Sustainable Development Goals (SDGs)’: economic, social and environmental costs. In other words, they tried to reveal the impact of ‘traditional trenching’ or ‘open- cut excavation’ to the existing infrastructure and thus suggested the need of using other alternative or technologies to install and/or maintain utilities. Economy is a matter of revenue and expenditure or cost. That means the gaining/generating and/or loss of income and exposure to costs particularly the unnecessary and avoidable ones.

Street works (especially that involves frequent excavations to the existing city infrastructure) incurred costs such as: direct costs (DCs)—of owners or operators of the infrastructures due to strike damages during the project life cycle especially construction, maintenance etc., Indirect Costs (ICs)—additional costs due to loss of businesses and Social costs(SCs)—those due to street works but imposed up on other users rather than the utility companies socially and environmentally, those Makana et al.(2019) collectively called as “true/full cost” of street works.

According to McMahan et al.(2006) as cited in Hojjati et al. (2016), DCs (of excavation) and SCs(of traffic congestions due to street works only) of UK were estimated to be ~£1.5 billion and~£275 million (5% of the whole congestion= £5.5 billion per annum) respectively.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Individual's, community and in general country's economy can be negatively affected due to such costs for example like that of UK (Hojjati et al., 2016). UK researchers made a lot of contribution to the estimations of such costs to create awareness and decision making on the related problem.

Among many of them, the above cited: McMahon et al. (2005, 2006) cited in Makana et al. (2019) and Hojjati et al. (2016)—estimated DCs and ICs of infrastructure works (“the real costs of Street Works”), Makana et al. (2019) developed methodology for cost estimating of utility strike and Hojjati et al. (2016) themselves also tried to develop a *tool* for such purpose in terms of sustainability. Moran et al.(2017) as well attempted to develop a *tool* to estimate the economic benefit of joint or cooperative work of utility and/or infrastructure service providing and related bodies.

As discussed earlier, most of the identified impacts of infrastructure works by Santos et al. (2021) can be considered as impacts that directly (‘direct costs’) affect economy and/or sustainable development.

Some authors (Santos et al., 2021; Moran et al., 2017) tried to identify adversely affected group of victims and the specific costs/impacts due to infrastructure work on public roads or streets. Those groups of victims and their incurred specific costs/impacts can be expressed as in the following table:

Table 2.3: Group of victims & impacts due to street reworks or frequent excavations in city

No.	Victims group	Specific incurred costs
1	Road user	Delay costs, increased vehicle operating costs, road safety
2	Local businesses	Lack of footfall and increased delivery costs from diversions and street closures
3	Residents	Health dis benefits associated with traffic and noise pollution, safety
4	Environment	Pollution, degradation due to overconsumption of resources(construction materials)
5	Road authority and Utility company costs	Unplanned maintenance resulting from road deterioration that can occur in the vicinity of an opening

Source: author's summary of extracted content of (Santos et al., 2021; Moran et al., 2017)

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

As already discussed, many other authors also used different terminologies to express the impacts of infrastructure work, tried to developed tools and indicators formulae or equations to calculate/estimate them in different ways, all revolving around a common theme, “economy” and or “sustainable development agenda”.

All of the impacts discussed earlier can be generalized into two main categories: (1) Additional expenditure to restore, replace the system of infrastructure services and treatment of ill or injured persons, (consuming more additional resources despite scarcity) and (2) Loss of income generation (loss of productivity) due to accidentally affected productive force, infrastructure service and business.

2.5 Mechanisms of excavation impacts Estimation

To simplify the method of calculating or estimating and comparing the ‘total’/ ‘real’/ ‘true’ costs for policy making and/or decision making to use the traditional open cut excavation method or other alternative technologies to develop new, or to maintain, repair or upgrade the existing city infrastructures, or to implement alternative technologies, some researchers (Hunt et al., 2014; Jung and Sinha, 2007) tried to develop formula/equations.

For instance, Jung and Sinha (2007) formulated two equations used to estimate and compare the impact/cost of excavations to infrastructure particularly, ‘open cut’ versus trenchless technology methods for pipeline construction as follows:

$$TC_{OC} = C_{DIRECT} + C_{SOCIAL} + C_{ENVIRONMENTAL} + C_{OTHER FACTORS} \text{ ----- } 2.1$$

$$TC_{TT} = C_{DIRECT} + C_{SOCIAL} + C_{ENVIRONMENTAL} + C_{OTHER FACTORS} \text{ ----- } 2.2$$

where, according to them, TC_{OC} = total cost of open-cut method; TC_{TT} = total cost of trenchless technology; C_{DIRECT} = earthwork cost, restoration cost, overhead cost, and so on including material, labor, and equipment cost; C_{SOCIAL} = traffic delay cost, income loss of business, and so on; $C_{ENVIRONMENTAL}$ = noise pollution cost, air pollution cost, and so on; and $C_{OTHER FACTORS}$ = productivity, safety, structural behavior, and so on.

Hunt et al. (2014) also developed method used to estimate cost of sustainability ($S_{sustainability}$) of infrastructure/street works in the sustainability point of view as follows:

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

$$C_{\text{SUSTAINABILITY}} = C_{\text{ECONOMIC (DIRECT+INDIRECT)}} + C_{\text{SOCIAL}} + C_{\text{ENVIRONMENTAL}} \text{-----} 2.3$$

However, except some of the authors that developed infrastructural works (excavation) impacts or costs estimation mechanism such as Hunt et al. (2014), the only highlighted the need to consider it, the rest of the authors did not considered the ‘time element’ – as the time before, during and after construction in their equations according to them, but did not consider frequency of events/earth works. To also fill such gap(not considering time effect or repetition of excavation activities), this new research modified models those formerly developed for cost/impact estimation considering the effect of frequency of earth work and or/street work events as already expressed in earlier section.

In belief of the author of this new research, no matter the way different authors categorise and express the component of the impacts, but anyone who is going to estimate or calculate the ‘actual/real costs’ or impacts needs to seriously consider the frequency/repetitions of maintenance and/or repairing work of existing city infrastructure beyond the assumed/expected reasonable period and make sure the inclusion of all relevant components of the impacts for a particular work of such events.

Researching for the impacts of utility strikes and/or infrastructure damage is good and important to make aware the concerning bodies. Unlike those previous literatures, this new research not only consider the impacts of such damage and/or strike to utilities and street infrastructures, but also the root causes of the repeated(unnecessary)excavations that negatively contribute to one’s economy. Therefore, the next suction and sub-sections discusses with these issues.

2.6 Causes of frequent excavations to existing city infrastructures

Although it is not explicitly and consistently debated in the relevant previous works, systematic reviews of literature, observations and experiences show that there are chains of causes: *root causes* (natural and human actions and/or combination of the two) that results in failure (damage, deterioration and/or obsolescence) and hence dysfunctional of infrastructure—the intermediate causes that in turns result in to the need to repair and/or upgrade—the immediate cause for excavation in general and frequent excavations (infrastructural rework) in particular.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

More or less, both intermediate and immediate causes are intuitively and scholarly known but not the root causes. However, comprehending the root causes of infrastructure damage and hence that of frequent excavations is very important to protect the vital and expensive utility assets. As, investigation for ‘root causes and impacts of frequent excavations’ is one of the key questions and objectives of it, this new work in its subsequent sections mainly focused on the investigation of root causes with more emphasis to the human behaviors/actions (Al-Bayati and Panzer, 2020) which may be manifested by technical and technological, political and cultural /behavioral practices of infrastructural stakeholders.

In this new research, most of the following sections and sub-sections specifically, the notion of ‘investigation of the root causes of frequent excavations and/or damage of existing city infrastructure’ will be built up on the idea of “infrastructural stake holders’ behavior—the human factors” that introduced by these authors but, in a more comprehensive manner than them.

As mentioned earlier, *root causes* are the origin or beginning source of failure of infrastructure that leads to the need for frequent up grading and/or repairing of existing city infrastructure — infrastructural ‘reworks’ (Love et al., n.d, 2013, 2019). These infrastructural reworks may include undertakings such as maintenance (regular/routine or reactive), repairing, rehabilitation, expansion and /or upgrading of the existing facility.

These in turn inevitably involve excavations (earth work) particularly, for city infrastructures that are interdependent and buried (Ouyang, 2014; Luo et al., 2019; Rahman et al., 2009; Bekele, 2018; Wallace et al.,2003; Wilbanks & Fernand ,2013; Michele and Daniela,2011) underground within right of way(ROW).

However, in its broad sense, the root causes include but not limited to: natural and/or environmental actions/ catastrophes—Earthquake and/or volcanic eruption, land sliding and/or subsidence, climate change results such as wind, hurricane, tornado, tsunami, flooding from a storm surge, rise of sea level, ripple — high intensity rain (Greiving et al.,2021; Infrastructure Report Card, 2021; Unterberg ,2017) — that are being occurring in many world countries , human actions—technical, political, behavioral and/or cultural (Heymans et al.,2019;Al-Bayati and Panzer,2020;Wallace et al.,2003;Love et al.,2013; Love et al.,2019; Hastak,2001;) or combinations (Matthew, 2003) of them.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

2.6.1 Natural and/or Environmental actions

Environmental actions and naturally occurring forces such as: tsunamis, earthquakes, heavy rainfall, flooding, landslides, flash floods etc. (Greiving et al., 2012) disastrously damage the existing functionally and spatially interdependent city infrastructures. Because they are not precisely predictable and avoidable (though happen repetitively in many cities), a number of world countries particularly the city communities had been suffering from them and hence nowadays, the notion of ‘resilient city’ (Sierra, 2011) is gaining more emphasis and worldwide recognitions.

Greiving et al. (2021) for instance, reported that earthquake and flood are the main disasters affecting Latin America cities –about 80% which affects more the poor social class. According to them, Lima (a capital of Peru—one of the Latin America countries) and which shares some common characteristics with Addis Ababa city. The similarities include “having large population, involving in main economic activities such as commercial and industry, presence of unplanned, disorganized and unequal urban growth, affecting mainly its poor population” was frequently affected by the most frequent floods and extreme rains among others most damaging events such as earthquakes and landslides respectively.

Similarly, Dagnachew (2011) reported that Addis Ababa is also prone to flood due to its location—at the toe of Entoto and other surrounding mountains or plateaus. He also pointed out other infrastructural management related factors such as the case of road and/or pavement damage in Addis Ketema sub-city by disastrous flooding or runoff. Among the recent floods reported by all most all of world multimedia, particularly the disastrous one of Libya was unforgettable. From long history up to recent, there has been reported disastrous damage to life and existing infrastructure of world cities.

Earthquake for instance, was one of the disastrous naturally occurring and damaged infrastructures (Muguruma et al., 1995; Esper and Tachibana, 1998; Zohar et al., 2017; Yashiro et al., 2007) in the long history. The recently occurred earthquake in Turkey (Portillo and Moya, 2023) according to the reports of many national and international Medias was the devastating natural phenomena damaged life and infrastructures. The other root causes and concern of this

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

research are those related to human intentional and/or unintentional actions and will be discussed in the following subsequent sections.

2.6.2 Intentional and unintentional human actions as root causes of FEECI

According to literatures, human actions/practices that cause damage or failure to infrastructures hence lead to frequent excavations or vice versa, can be categorized in different ways and levels. In broad and sub-category, they include: Technical (Poor engineering practices and lack of technology/alternative solutions of utility installation), Political (corruption, unnecessary interference or influence to technical requirements, ‘pork barreling’, conflict/war, terrorism), Legal/Statutory (absence and/or inapplicability of standards, code of practice, regulations, directives and guidelines, appropriate infrastructural asset management in general) and Cultural/behavioral (misuse/handling of public infrastructure, lack of ownership feeling, theft or vandalism).

Generally, these human actions /practices can be either (1) intentional/deliberate—‘will full’ (Wallace et al., 2003) such as ‘corruption’ and/or political leverage (Echendu et al., 2020; Parkin and Sharma, 1999), ‘terrorism’ (Bram, et al., 2002) and/or ‘vandalism’ (Leong , 2005), ‘theft’ and ‘misuse’/poor handling ; (2) unintentional—‘error’(Love et al., n.d, 2013, 2019) or (3) combination of them that may occur at one or more/all of the stages of infrastructural projects.

Investigations of root causes and impacts of frequent excavations to existing city infrastructures were overlooked as lack of robust and directly related literatures evidently shows. Evidently, that is why almost all of the previous researches only focused on ‘regular excavation’—the scheduled and mandatory one, and its damage but not frequent excavations and their consequences particularly, the causes of strike damages and their impacts.

Among the previous literatures, few authors (Khogali and Mohamed, 1999; Matthew, 2003; Al-Bayati and Panzer, 2020; Love et al., n.d, 2013, 2019) tried to explore human actions related causes. Al-Bayati and Panzer(2020) for instance, identified ‘human actions/behavior’ and ‘lack of appropriate information of exact location of underground utilities’ as the ‘root causes’ of damage to underground utilities in America.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

However, because they focused on the behavior of workers (human) those excavate/dig and locate utility only, their study as a root cause of infrastructure failure and hence frequent excavations or vice versa, is not comprehensive and generalizable but could be the base for further study such as this new research as already mentioned.

2.6.2.1 Technical: Poor engineering practices & lack of alternative solutions/technologies

I. Poor engineering and management of infrastructure

Engineering particularly, civil engineering involves range of stages and/or phases those finally provide us with different important infrastructures for our livelihoods and welfares. Although they are not listed in similar way by different authors of existing literatures, the project life cycle or phases of civil engineering projects according to Guo et al. (2010) include: planning, designing, implementation/construction, commissioning, utilization/operation, maintenance and decomposition.

Each of these phases also involves different activities that are mainly executed by human who in turn are not completely free from errors ('mistake', 'non-compliance to standard (or violations of it)' and 'slips, lapses of attention' and acts of omission and commission) according to Love et al. (2019). These human errors or origination of poor engineering practice have a probability of occurring at one or all of the stages/phases of civil engineering projects. Poor engineering and management practices are manifested by: poor planning and designing, poor construction/implementation, poor utilization/operation and poor maintenance of infrastructures. They are all a function of human actions/decision or practices that eventually results in to early failure (damage, collapse, deterioration and/or obsolescence) of infrastructures.

Poor infrastructure planning and designing practices: Planning and designing stages cannot be seen separable. Planning of city and its infrastructure is also cannot be seen separately as city is dependent on and manifested by its infrastructures. While planning involves plan testing and evaluation (Parkin and Sharma, 1999) which has two steps (preliminary and detail), design is more concerned to technical aspects or engineering part of the stage.

It involves assumptions or considerations, estimations, calculations of external and internal forces or actions on the particular facility, its required strength and/or durability. This is to

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

ensure that the infrastructure withstand such internal and environmental factors and properly function throughout intended life which is ever expected to be longer with optimum maintenance & operation costs from the economic point of view.

At this stage, structural, architectural and other design types for instance, are carried out by engineers, architects and/or urban/city planners. According to some scholars (Dyer et al., 2019; Lay, 2013; Gann et al., 2011; Shan and Yai, 2011; Matthew, 2003), these designing professionals need to have physical/artistic and natural science knowledge acquired from applied physics, mathematics as well as experiences and are also expected to be responsible and accountable for safety, economic and aesthetic aspects of their design outputs—structures and/or infrastructures.

From experience and content of the literatures however, if the stakeholders (technical and non-technical) do not perform according to expected ethical and responsibility stemming either from their intentional (corruption) or unintentional (error) actions, it results in poor quality, non-standard and under capacity, which in turns result in early and frequent failures (damage/collapse/deterioration and obsolescence) of the deliverables particularly, infrastructures. As such, the chain of causes may continue up to the need of frequent reactive maintenance and/or repairing of damaged infrastructures or upgrading/renovating of obsolete facilities. This in turns obligates to undertake frequent excavations or rework of existing infrastructures.

Poor implementation/construction practices of infrastructure: implementation/construction is the stage at which the intended project/conceived and designed deliverable will be converted into real or physical asset by deployment of resources (consumption of materials, involvement of man power, tools, technologies and equipment) as per the plan and design.

It is at this stage where the high possibility of deviation and/or change (for good or evil) of involved resources (construction material, man power, tools and equipment) and methods/techniques of construction from the one specified by plan and design. This deviation occur either due to intent ended (corrupted), due to unintended (erroneous) human actions or due to the combination of the two. Although regardless of the purpose, all of them eventually result in physical and/or functional prematurely failure of the facility, it is important to investigate and scientifically identify the root causes of FECCI for a particular case of an environment.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Even if the plan and design is correct, appropriate, according to Khogali and Mohamed(1999) it was known that there will be the chance of deviation and hence failure of the infrastructure which in turns cause need for reactive maintenance/repair or re-building part or whole of the failed/damaged facility particularly, the interrelated city infrastructures. This implies that inappropriate quality of materials, workmanship, tools, equipment and techniques were applied in construction (Johari and Jha, 2019; Matthew, 2003; Infrastructure Report Card, 2021; Fwa1 and Sinha, 2015; Ishimwe et al., 2021) or installation of infrastructure. It may be also due to poor supervision (Echendu et al., 2020).

Poor operation/utilization practices of infrastructure: operation or utilization stage is the relatively longest period of time ranging from the completion of construction/installation and/or handover to the demolition of the aged facility. Though, infrastructures are expected to fully and properly serve for relatively longer design life time, it can be affected by different phenomena.

Among this misuse of the existing infrastructure is one of humans' actions particularly, behavioral related one. For instance using road for both higher volume and loads of traffic beyond its design capacity can result in early failure of the road (Fwa1 and Sinha, 2015; Ishimwe et al., 2021). Misusing walkways for vehicular and/or construction materials stocking purpose(Echendu et al.,2020) can cause early and frequent failure of it in addition to exposing pedestrian to vehicular accident as they try to share roadway with motorists.

It was also reported that community misused drainage systems as disposal space of different solid wastes (Mangizvo, 2010).Therefore, committing such misusing and others actions such as theft, vandalism(www.ijrte.org/wp-content/uploads/papers/v10i3/C63550910321.pdf) that result in early and frequent failures of existing infrastructure can in general be said poor operation/utilization or management practices of human.

Poor practices of infrastructure maintenance: Several authors defined, categorized and advocated 'maintenance' (Al-Turki et al., 2014; Emeasoba and Ogbuefi, 2013; Leong, 2005; Khogali and Mohamed, 1999; Bucher and Frangopoulos, 2006; Matthew, 2003) in which all most all of them agreed up on that it is necessary to enhance the performance and life time of an asset especially the regular and pro-active type. However, poo maintenance practices for example, not undertaking it regularly/routinely or delaying maintenance schedule (Lemer, 1996;

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Michele and Daniela, 2011) can result into the failure of infrastructure which in turn causes arbitrary and frequent repair and excavations/reworks.

II. Lack of alternative solutions/technologies & guidelines for utility installation

Alternative solutions or other methods than ‘traditional open cut’ for either installation or detection of underground utilities have been available. These include the implementation of initiatives such as surface utility engineering—SUE (Metje et al., 2020; Royal et al., 2010), Mapping the Underworld—MTU (Metje et al., 2007) and/or utilization of city’s underground spaces (Hunt et al., 2016), use of spatial data infrastructure—SDI and geographic information systems—GIS (Bishop et al., 2000) for documentation of information on exact location of buried utilities.

Utilization of Trenchless technology—TT (Najafi, 2005 as cited in Jung and Sinha, 2007; Khogali and Mohamed, 1999) and/or multi-utility tunneling—MUT (APWA, 1997; Cano-Hurtado and Canto-Perello, 1999; Luo et al., 2019; Hunt and Rogers, 2005; Rogers and Hunt, 2006; Hunt and Rogers, 2014), for installation of underground utilities in order to avoid or minimize frequent excavations and hence damage of infrastructures also the other worldwide popularized alternative solution to open cut/traditional technique utility installation method, TT and/or MUT has been advocated by many scholars.

Trenchless technology (TT): Jung and Sinha (2007) advocated the use of TT stating it as the most economical and more efficient method of underground infrastructure works than other technologies comparing it with traditional open-cut excavation.

According to Najafi (2005) as cited by Jung and Sinha (2007), TT was defined by North American Society of Trenchless Technology—NASTT as “*a family of methods, materials, and equipment capable of being used for installation of new, replacement, or rehabilitation of existing underground infrastructure with minimal disruption to surface traffic, business, and activities*”. The authors described the use and sub-categories of TT as depicted by them as in figure 2.2 below.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

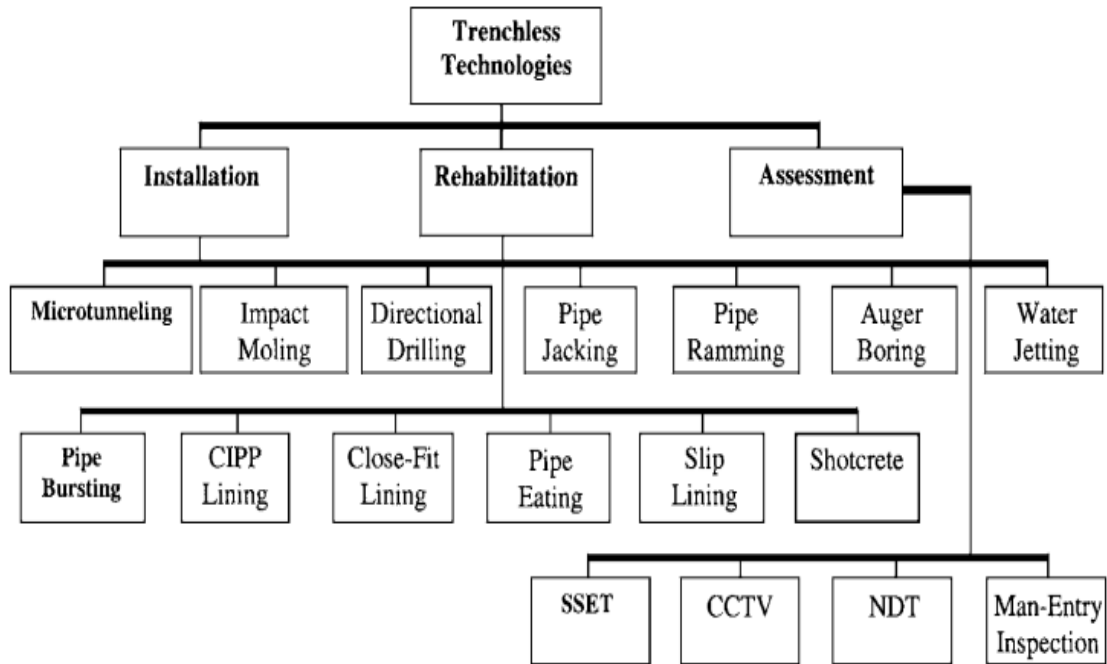
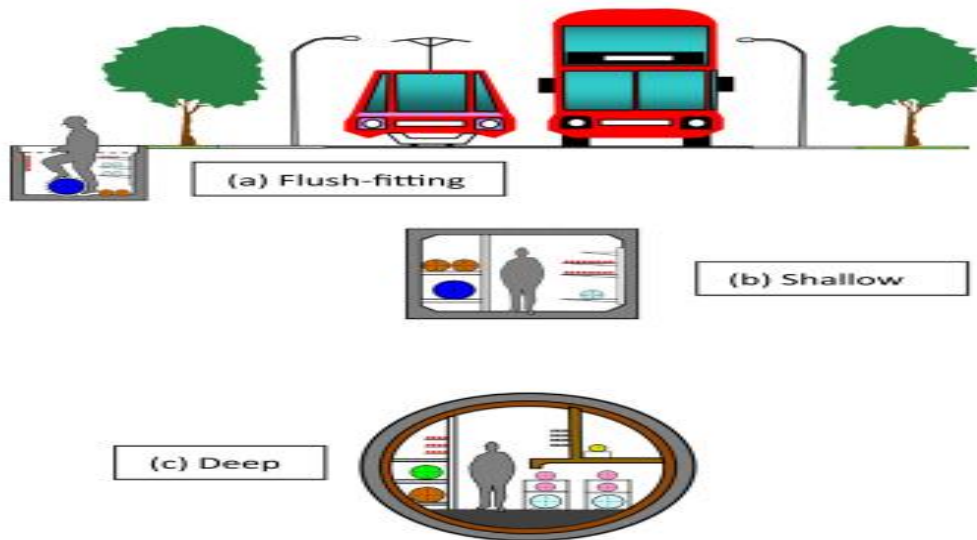


Fig.2.4: Trenchless technologies (Jung and Sinha, 2007)

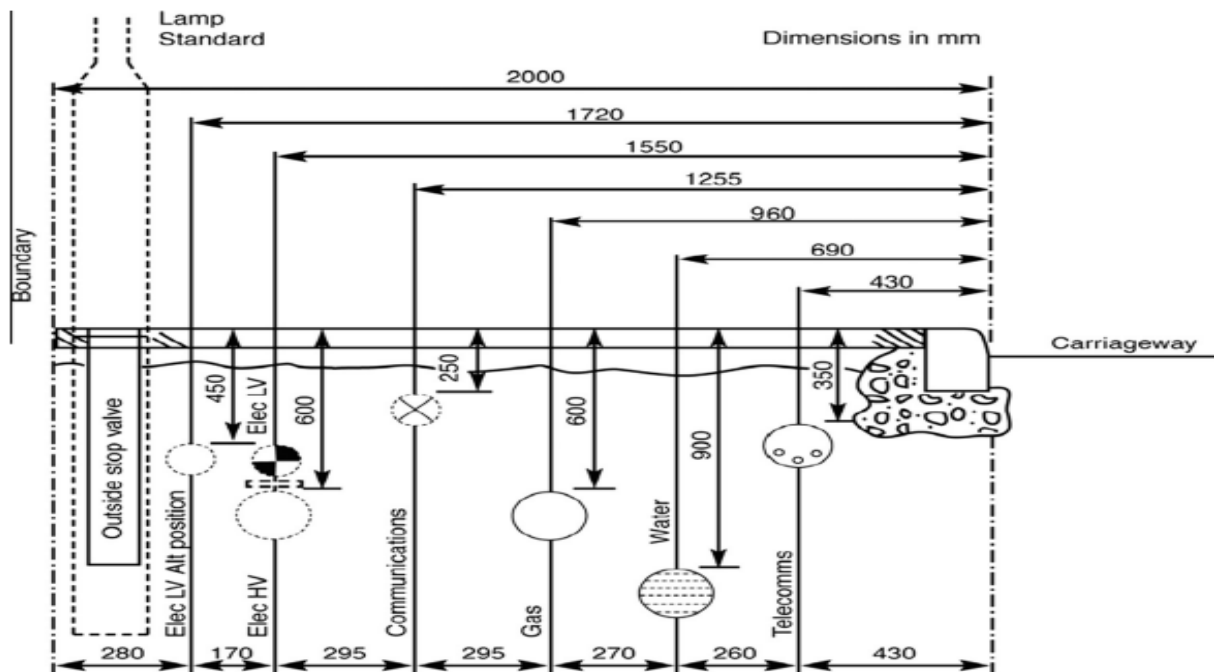
Multi-utility tunnel (MUT): was defined as “any system of underground structure containing one or more utility service which permits the placement, renewal, maintenance, repair or revision of the service without the necessity of making excavations; this implies that the structure is traversable by people and, in some cases, traversable by some sort of vehicle as well” (APWA, 1997 as cited in Hunt et al., 2014).

According to Hunt et al. (2014), MUT are globally applied in more than 60 different forms depending on profile, depth, material, type of accommodated utilities and extent. The following figures (a) and (b) reproduced from these authors indicate that types or forms of MUT and standard and/or guidelines of utility installation applicable in UK as also reproduced from (NJUG, 2003) by them respectively.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets



(a) 'Different types of MUT construction'



(b) 'NJUG guidelines for utility installation in the UK (NJUG, 2003)'

Fig.2.5: Different types of MUT construction (a) & NJUG standards for utility installation in the UK (b)

On the other hand, according to the report of paper prepared by Zeiss and Shinoaki (<https://gita.memberclicks.net/assets/Final White...>), there are also advanced technologies such as

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

remote-sensing tools – ‘electromagnetic conductivity(EMC)’, ground penetrating radar–GPR, inertial, acoustic, very low frequency (VLF) profiling, electrical resistivity imaging, borehole geophysical and video logging, crosshole seismic testing, seismic tomography, microgravity surveys, seismic refraction, and magnetometer’ used to detect or find location of buried utility.

In addition to these, Jung and Sinha (2007) mentioned closed-circuit television–CCTV and sewer scanner and evaluation technology–SSET. According to the literatures, these are used to detect almost the exact location of underground buried utilities before starting excavation in the vicinity hence prevent damage of such utility.

It is obvious that while availability and proper application and/or utilization of these alternative solutions and advanced technologies in development, maintenance and repairing works of infrastructures particularly, underground utility lines is a vital method of avoiding or minimizing the frequent excavation to the existing city infrastructure, lack (absence and in efficient utilization) implementation or use of them results in to the need for frequent excavation and repeated damage of existing infrastructures.

In fact, infeasibility (technically and economically) in all conditions, places and time as the initial cost/construction/investment cost/ of MUT was identified to be expensive and not economical in short term but in long term than the traditional method (Hunt et al., 2014), it could not be used intensively but need to be used at a places in the city where they are critically important.

2.6.2.2 Political and administrative interference to infrastructural issues

Failure (damage, collapse, deterioration and/or obsolescence) of structures and/or infrastructures that attributes to political actions and/or decisions can be occurring in three or two ways: First when a group of and/or individual person with public power/authority corruptly used the power (Abuse of power).

To this end, most often infrastructures with poor quality and hence frequently and prematurely failed/damaged and obsoleted can be developed as new investment or maintained and/or repaired under inappropriate decision of such corrupted authorities. This may be either by the so- called “*pork barrel*” (Parkin and Sharma, 1999) – diverting or misusing allocated budget of a particular

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

project for other purpose/advantage (Echendu et al., 2020) or by unnecessary interference/influence of political decisions in to technical requirements. For example, enforcing technical persons or professionals to design or implement infrastructure against standards requirement or to complete work more urgently than the time naturally required or to alter particularly, under designing the facility are some of such conditions.

The second condition is when an individual or group of people acting against those in power commit a terrorism action (Bram, et al.,2002) and deliberately damage/destroy life and/or properties particularly, infrastructures. The other third condition is when there is a conflict (civil war and/or war) between a group of people/countries (Tesema and Kinfu, 2021; Bulatova et al., 2022; Moffett, 2022) in one country or different countries. In any ways of these, all damages of the existing infrastructure finally lead to the need for frequent excavations in terms of time or location within city to reconstruct and/or repair the damaged facilities or vice versa.

2.6.2.3 Lack or inapplicability of infrastructural statutory initiatives and guidelines

The absence, shortage and negligence of using codes, standards (Shapiro, 1997) and/or difficulty to use the regulations due to the complex and ‘inscrutable’ standards (Sudipta et al., 2020) contained in it, as well as inapplicability of statutory though available as standard as in the UK’s National Joint Utilities Group—NJUG (Hunt and Rogers, 2005; Hunt and Rogers, 2006) lead to the inappropriate management (through the stages from initiation to demolition) practice of infrastructures.

2.6.2.4 Cultural/behavioral practices of infrastructure users or community

This is the condition under which individual or community reflect poor behaviors and/or culture of using existing infrastructure, particularly public assets with a sense of no or less ownership. This is further manifested by: miss using of infrastructure, theft and/or vandalism (Chingozha and Zvokuomba, 2021) practices of individuals or community of one’s city and/or country.

Miss-using is one of the main manifestations of poor culture of infrastructural handling and usage of individual or community. This includes human actions such as: illegally dumping of solid wastes in not permitted areas for example, drainage infrastructure systems (Mangizvo,

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

2010) which eventually cause failure of infrastructure and result in to frequent excavations or reworks.

2.6.3 Intermediate Causes

Failure: damage/collapse, obsolescence

As the name indicates, this type of cause is the connecting bridge between root causes and immediate causes. That means, being caused by root causes (gradually as the cumulative results of actions and /or suddenly occurring), it in turn causes the immediate cause — ‘failure’ and/or dysfunction of infrastructure. Inability of existing infrastructure to provide expected services or *failure of infrastructure* can be manifested by failure forms such as: obsolescence (Lemer, 1996; Matthew, 2003), damage/collapse (Love et al., 2013, 2019).

2.6.4 Immediate Causes

2.6.4.1 The need for constructing and/or expansion of infrastructures

Constructing new facilities and/or expansion of the one already available in a given area particularly, city may be necessitated due to different reasons say an increased demand of it that also caused by different factors. Earth work involves excavation, fill, compaction and cart away (Jung and Sinha, 2007) is an inevitable activity during undertaking of such engineering projects.

On the other hand, value of scarce urban land and the need for its economical use enforce the urban/city environments to be crowdedly or densely populated and hence having concentrated and/or networked infrastructural systems than the rural and sub-urban areas (Jim, 2003). In such vicinities, even if the intensions of undertaking earth works and other construction activities is to construct a typically new facility, the activities particularly, earth works unavoidably undertaken to the existing infrastructures of city especially, within a ROW(Khogali and Mohamed, 1999).

2.6.4.2 Maintenance, repairing and upgrading/expansion of existing infrastructures

Maintenance, repairing, upgrading and/or expansion of existing infrastructure involves several civil engineering and/or construction works which includes earth works particularly excavation(Matje et al., 2015; Santos et al., 2021; Makana et al., 2016) among other activities.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

According to the literatures, though such earth work (excavation/cut, fill, compaction, cart away and other related activities) is important for such purpose, it also inevitably imposes several impacts even planned and undertaken periodically.

On the other hand, its impacts can weigh than the benefits or importance of excavation or earth work, if it undertaken arbitrarily and frequently (Sahle, 2019; Hunt and Rogers, 2006; Luo et al., 2019) to existing city infrastructure. Arbitrary and frequent excavations to the existing infrastructure in general and to the city infrastructure (streets, road side greeneries and utilities) in particular, are uneconomical, unsafe and un-aesthetical actions.

In order to avoid/minimize the overall economic/sustainability impacts (Pilvar, 2015) of such repeated excavations on city infrastructures to the possible extent, it is important to investigate the causes and impacts of such frequent and arbitrary excavation which is the main objective of this new research. Therefore, this new research is not to completely condemning ‘excavations for infrastructural works’, but aimed at investigating root causes and impacts of the unnecessarily repetitive excavations in the way that enables minimizing and/or avoiding them—optimization of scarce resources (Agudelo-Vera et al., 2011) there by implementing the contemporary agenda of our world—“sustainable development” (Goodland and Daly, 1995 as cited by Parkin and Sharma, 1999; Echendu et al., 2020).

2.6.5 Summary and gaps of previous literatures on the problem understudy

City and its existing infrastructure have an overarching characteristic and linkage with civil engineering particularly, such as earth works (excavation, fill compaction etc.). Undertaking of excavation and/or trenching activity is common and inevitable in almost all of the civil engineering works and/or construction works (Metje et al., 2015). Within this concept, what should be clearly noted is that, although it may impose several impacts, planned/conventional excavations are inevitably undertaken to implement new infrastructure projects or renovate and/or upgrade the existing one. However, the problem is if it is undertaken frequently and arbitrarily (without plan or schedule) and as a ‘rework’ (Love, n. d, 2013, 2019) in a way it imposes overall economic and/or sustainability impacts (in terms of repairing costs, operational costs, Societal—health & safety/convenience impacts, Environmental and/or aesthetic aspects).

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

During excavation and/or trenching, damage may be occurred at least to one of the interrelated city infrastructures (Jim, 2006) in general and most likely in cities of developing countries. Especially, damages due to frequent excavations, to existing city infrastructures such as roads, sidewalks, interior or access roads and spatially and/or functionally interrelated utility lines such as potable water pipe, storm water drainage system, sewerage system, telecommunication cables such as fiber optics networking and power assets(Wallace et al.,2003). As a result, interruption of services, subsequent losses and inconvenience to users as well as repeated repairing hence frequent excavations resulting in to many other impacts has seemingly become a culture just “a commonly acceptable, a natural or just normal” perception in Addis Ababa city and/or community.

Many of previous literatures reviewed in this research tried to touch infrastructural works related issues in different angles. Most of them have put an effort to identify impacts of ‘infrastructural works’ and/or ‘street works’ in general and excavation in particular which they also expressed in different terms and categories. Some of them also tried to develop models or equations used to estimate those impacts and/or costs. Their several gaps that have to be filled by further research include the following:

1. Almost all of the researchers overlooked/ignored frequent and arbitrary excavations or reworks to existing city infrastructures, though the problem is commonly noticeable and has large scale impacts worldwide in general and in Addis Ababa in particular,
2. The root causes of such frequent and arbitrary excavations to existing city infrastructures, particularly that of Addis Ababa(capital city of Ethiopia) were not investigated scientifically and clearly,
3. Contribution of frequency or repeating of the events to magnitude of the impacts/costs in developed models of impact or costs estimation was not incorporated.

Thus, this new research filled such gaps not by totally condemning construction/infrastructural work activities such as excavation and/or trenching which is inevitable whether in implementing new infrastructures or maintaining and upgrading the existing one, rather, it investigate and/or identify the root causes of such frequent and arbitrary excavations to the existing city infrastructure of Addis Ababa in a way of minimizing and/or avoiding it. In addition, it modifies model/equation of impacts or costs estimating of such events building up on the previous models

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

but considering the frequency of the events. Therefore, it is important to develop conceptual framework of this research as in the subsequent sections and sub-sections.

2.7 Conceptual framework of the study

2.7.1 General Conceptual framework summarized from previous literature

From common senses and established knowledge of the areas, importance of city and its infrastructures, functioning system and their relationship with construction activities particularly, excavation can be conceptualized analogously to the importance of human organs system, health and its relationship with medication such as surgical treatment. For human, health or being healthy is to be at normal condition which is very important to be alive first and then being efficient productive in every daily life including economic activities to sustain life itself and to be successful within one's life span.

Although sometimes occurrence of disease or being ill is inevitable within lifetime, it is possible to prevent almost all diseases / illness/problems. To do so, diagnostic action (investigation and/or discovery) of root cause(s) is important. The principle "*Preventing is better than cure*" that often used by health professionals and many other researchers for instance, Heymann and Dar(2014), is power full and metaphorically best fitting to the concept of the problem under study in this research area. This is due to curing may be more expensive and riskier than preventing. Preventing by itself is possible and effective only if the causes (root, intermediate and immediate) are investigated and identified.

Again, the risk/side effects or impacts of curing on economy and/or life of the victim/patient may vary depending up on types and frequency of curing/remedial methods used for treatment. For instance, surgery may be relatively riskier and more expensive than injection, other treatments or preventive actions. Furthermore, from intuitions, common senses and scientific facts of the area, although it sometimes mandatorily recommended (not selective), frequent surgery to the same patient or to the same organ of the patient may be difficult and it may affect the function and life of that patient in many aspects irrespective of its ultimate goal is to cure the illness (Understanding Surgical Risks (<https://www.verywellhealth.com>)). The same is true for infrastructural system related issues particularly, frequent excavations/reworks. Likewise, the

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

investigation of root causes and impacts of frequent excavations to the existing streets and utility infrastructures particularly, that of Addis Ababa city in this research is very important to avoid and/or minimize the subsequent losses.

Relationship of street, utility infrastructures and functions of city Versus that of human body organs, health or life : just like in relationship of the skin, flesh and blood vessels or other internal organs of animals particularly human body, installations or locations of utility infrastructures systems/networks such as, electric power, telecommunications, sewer and/or storm water, potable water pipe lines are spatially and/or functionally interrelated with roads/streets along or across the lanes or sidewalks of most cities and particularly, in Addis Ababa city. Due to this, the excavation undertaken to upgrade, maintain and/or repair at least one of them in general, and the arbitrary and frequent excavation activities in particular, most probably result in to occurrence and propagation of damage of the other infrastructures and hence interruption services and incurred in to additional economic and sustainability costs like repeated and in appropriate surgical treatments may result in to partial damage or death of patients.

Concepts, synonyms and equation/model for impacts estimation: In this study, the term ‘frequent’ or ‘frequency’ contextually considered in terms of location and/or time — how many times and where (repetition, happening more than one times and locations) of an event—excavation itself and subsequent damage or vice versa and other impacts on the existing city infrastructures or in terms of attribution—belongingness of causes repetitions related to infrastructural stakeholders or utility providers (among the registered or occurred excavation events or subsequent impacts to the existing infrastructures). Again the phrases ‘frequent excavation or frequent trenching’ and/or ‘*earth reworks*’ are used interchangeably (being synonymous for the purpose of this research) throughout this research when and where sensibly necessary as also described earlier. Moreover, the term “Frequent excavation” is not only to refer to cutting, digging or trenching activities; but also, it was used in this research to mean every works from excavation, cutting in to whether paved or unpaved surface of the streets and or spaces, reinstating, compacting and cart away of the surplus material within city as also discussed earlier. This metaphorical expression was illustrated as in figure 2.6 which is the diagrammatic conceptual framework of the research.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Note that, whenever described in terms of monetarily value or cost, the total impacts (I_t) may be expressed by empirical equation and equals to the sum of expected impacts (of planned and/or an inevitable excavation/infrastructural works), (I_e) and the summation (\sum) of each impacts due to repetition (I_i) multiplied by its frequency (f_i)—the term which further modeled by regression equation as indicated in figure 2.7 by equation (2.4) indicating that frequency of excavations to the existing infrastructure is directly proportional to subsequent impacts on economy and/or sustainable development.

$$I_t = I_e + \sum (I_i * f_i) \text{-----2.4}$$

Although I_i is the general it can be decomposed into all identified components of a particular street work and/or repeated excavations impacts, in this case for instance in to : Repair/rework cost, Operational cost, Societal (health & safety/inconvenience) impacts and Environmental and/or aesthetical impacts(if any or when data are available or accessible for each).

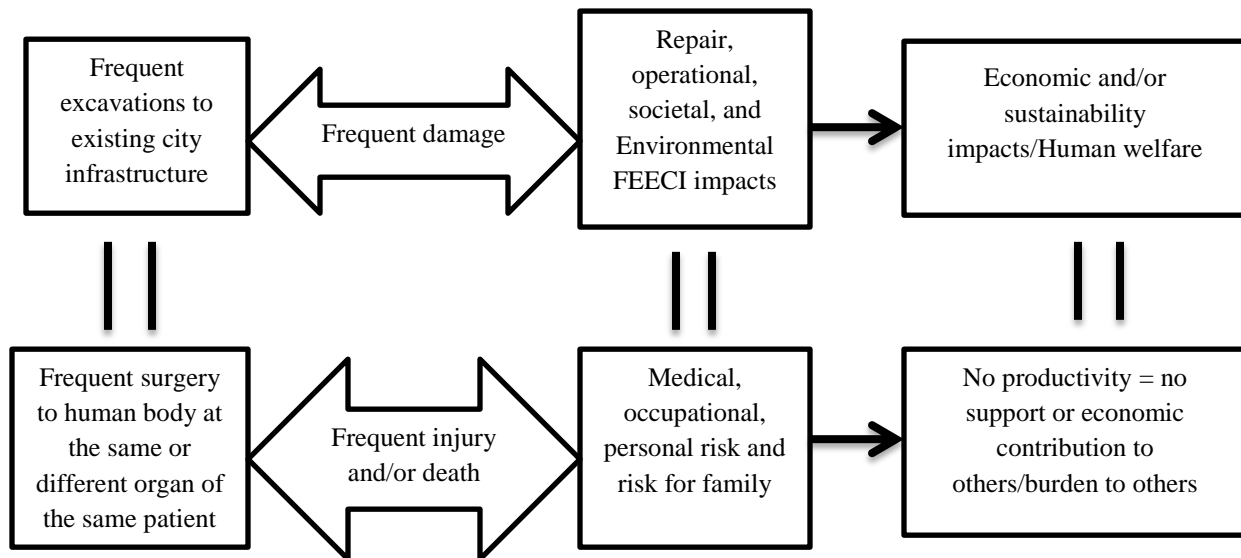


Figure 2.6: General conceptual framework of the study (by author)

In addition to the above general conceptual framework, detail flow diagram of the study can also be illustrated schematically as in figure 2.7 as follows:

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

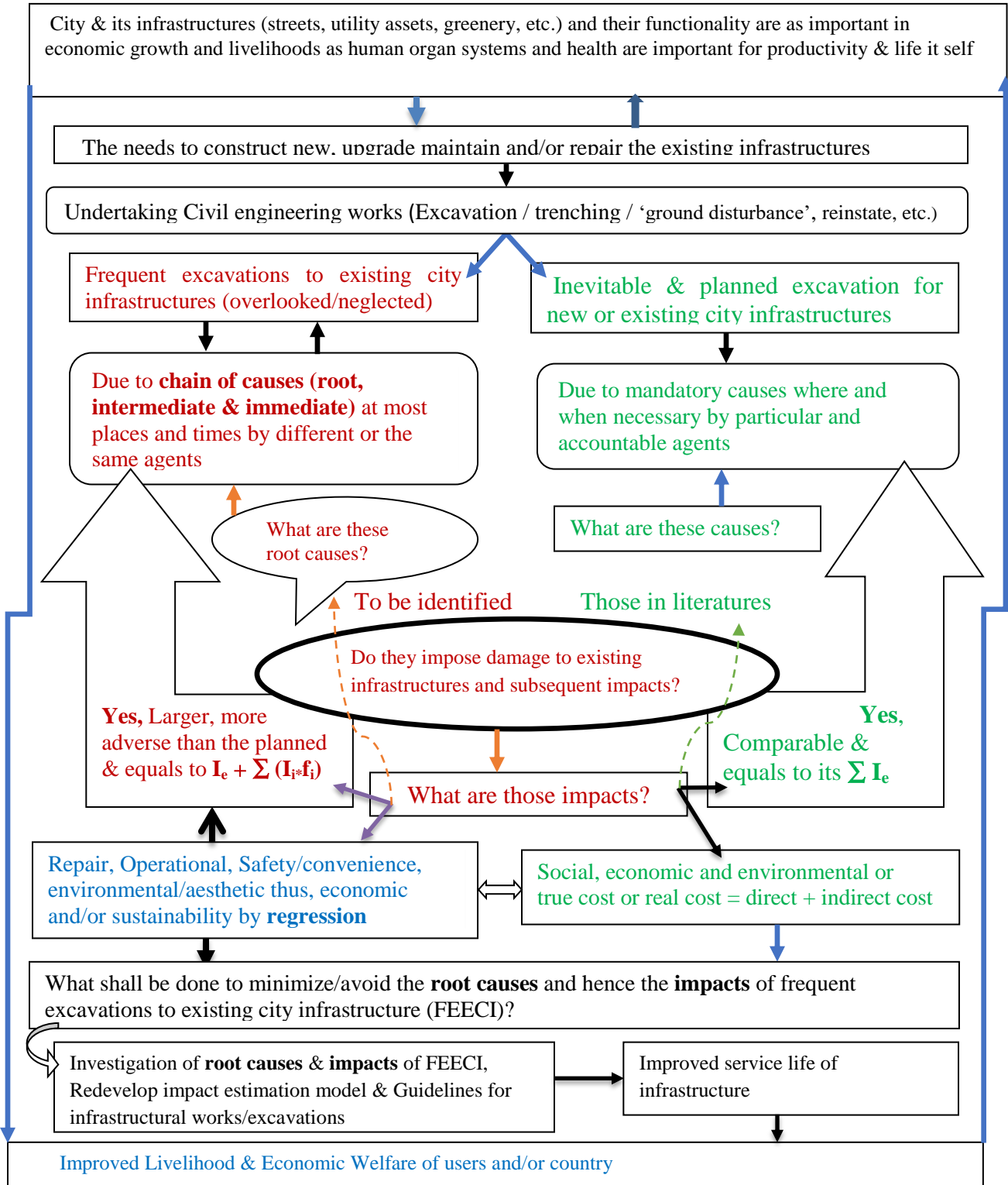


Fig. 2.7: Detail schematic description /flow diagram of the study (by author)

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

2.5.2 Specific Conceptual framework of the research

As already discussed earlier particularly in the general conceptual framework developed from the reviewed literatures related to the problem under study, there are visible and hidden causes and impacts of FECCI—however, not clearly identified yet needing further conceptualization within which the study shall be undertaken. That is why the researcher developed this specific conceptual framework as illustrated in figure 2.8 as summary. Thus, root causes and impacts of FECCI will be identified within this specific conceptual framework.

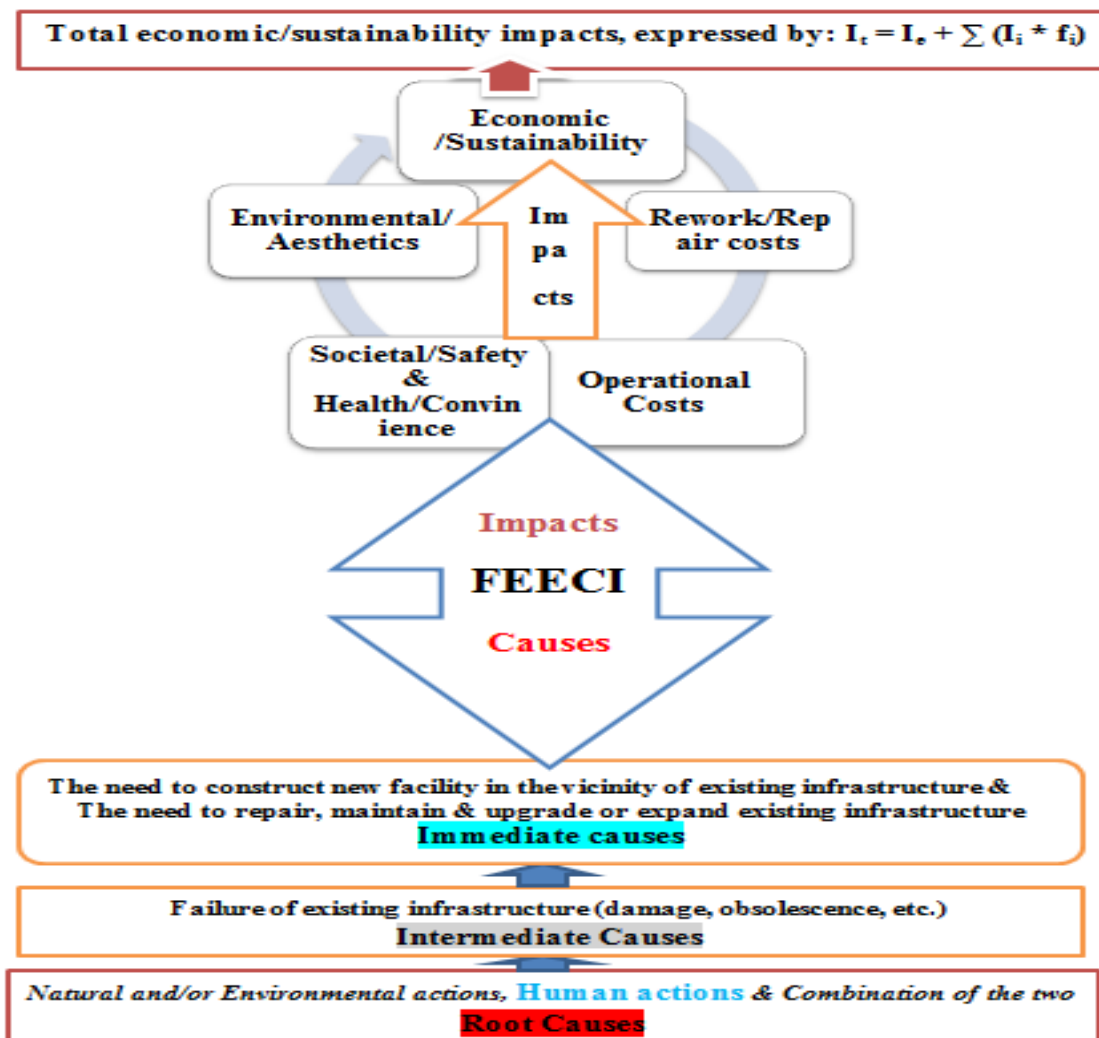


Fig.2.8: Specific conceptual framework of the research (by author)

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Research design and approach

Research design is the overall plan/strategy (McCombes, 2023) in which research is undertaken from the start to the end. To achieve the proposed goal, this research was designed in a mixed research approach—combination of both qualitative and quantitative research methods (Creswell et al., 2004) particularly, as observational case study in which survey (interview and questionnaire), field observation and desk studies—review of secondary documents (previous relevant literatures and of some selected excavation events) were used as data collection methods.

3.1.1 Research Type

There are several types of research based on categorization criteria and as such for a given particular problem under study, and for a given research, there is a possibility of being under more than one type of research at the same time as in the case of some authors (Assefa, 2008; Dinsa, 2015) as it was evidently deduced from their research done for partial fulfillment of their master degree.

Similarly, this new research in general being observational, it shares common characteristics in which it shows the characteristics of being more than one type. That means because it can solve a practical or real problem—frequent failure of city infrastructure and others related, this research can be categorized as an applied research type. On another categorical criterion, it can also be exploratory and explanatory research types as it tries to explore the reasons why the frequent excavations to the existing city infrastructure and/or failure of those infrastructures are the cases in Addis Ababa city or vice versa. At the same time, it is also descriptive research type as it tried to illustrate the whole nature of population, conditions, utilizes organized methods and expresses results, though it also involves mixed approach of research method employing both qualitative and quantitative type.

3.1.2 Description of Research Area

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

The study area for this research covers and delimited to Addis Ababa city which is located at $9^{\circ}1'29.9''$ N and $38^{\circ}44.813'$ E (<https://www.geodatos.net/en/coordinates/ethiopia/addis-ababa>). The city also called as 'Finfinni' or 'Finfinne'/according to several authors,(Geleta, 2014;Jalata,2010;Sirna,2018;Tesema,2018;Debelo,andSoboka,2022) and it was established 'spontaneously/organically'—without plan(Wubneh,2013;Tufa,2008;Erena et al.,2017) by Minellik II and his consort Empress Taitu (Minalu, 2014; Hailu, 2020; Melesse, 2004; Seifu and Stellmacher, 2021; Pankhurst, 1961) in 1886. The general map of study area, entire Addis Ababa City with its 11 sub-cities was illustrated bellow as in figure 3.1.

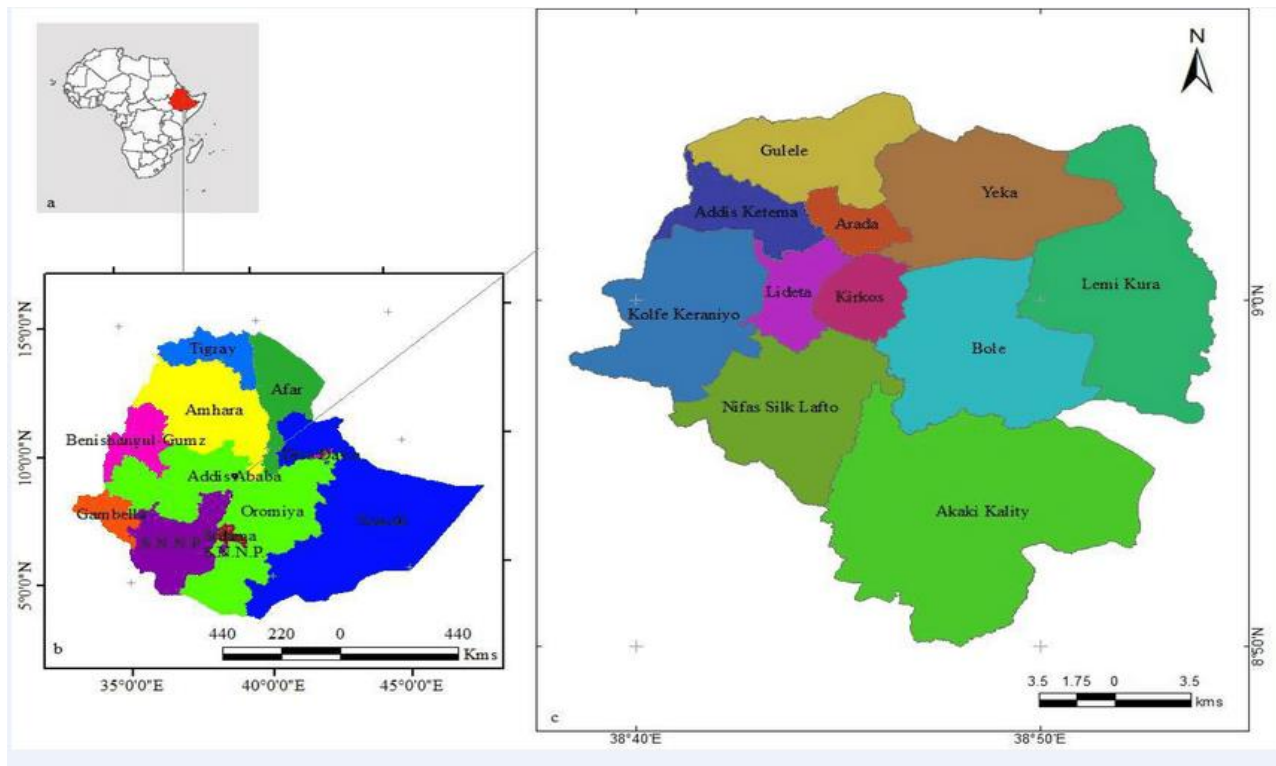


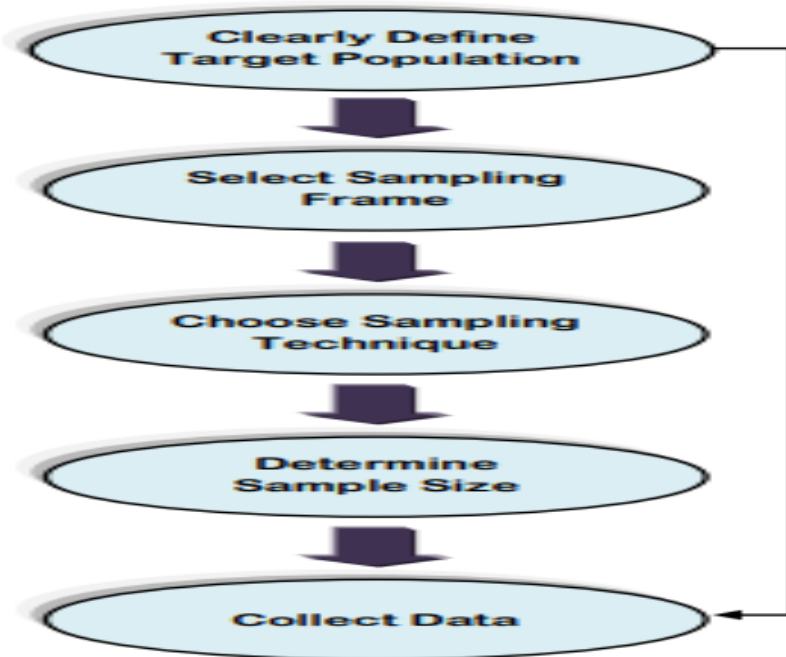
Fig. 3.1: Map of entire Addis Ababa (with the 11 sub-cities as study area) source: Ethio- GIS-2022

3.2 Research Methodology

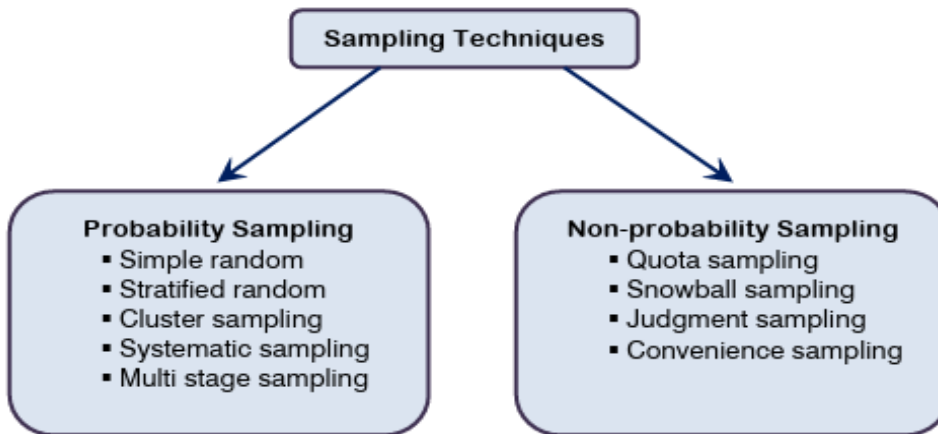
3.2.1 Sampling and sample size

According to scholars, sampling is a process of selecting or drawing some or taking all groups of individuals among the population that will be studied and conclusion will be drawn about. This process, according to Taherdoost (2016), has several stages and two techniques as indicated in figure 3.1 below.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**



(a) Sampling Process Steps



(b) Sampling Techniques

Fig.3.2: Sampling Process Steps and Sampling Techniques (Taherdoost, 2016)

As indicated in the above figure that was reproduced from Taherdoost (2016), there are four(4) steps of sampling processes and two sampling techniques/methods—‘Probability Sampling’ and ‘Non-probability sampling’ in general. However, in this research particularly for interview and questionnaire surveys, non-probability sampling method specifically, judgment/purposive sampling was employed among the two techniques. Field observations of

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

excavation being undertaken within the territory of Addis Ababa city (entire population) but mainly focusing on those at central zone or region of the city during daily activities commute and purposive tour and traverse were undertaken by the researcher. Tools such as smart phone to capture photo graphs and videos as well as checklist format (see appendix B1) with pen and pencil to take notes and tick the appropriate lists were utilized. The case studies of several purposely selected sites were also undertaken.

For the qualitative interview data collection, personnel or professionals of purposively selected target populations (both federal and Addis Ababa Infrastructural companies) were interviewed. These target population that involved in interview include: Addis Ababa City Roads Authority (AACRA), Addis Ababa Water and Sewerage Authority(AAWSA),Ethiopian Electric Utility (EEU), Ethiopian Telecommunication Corporation (Ethio-telecom)—ETC and Addis Ababa City Administration Urban Beautification and green development Bureau—AACAUbgdb.

In addition to the field observation and interview, survey particularly, questionnaire data collection tool also used to supplement them. Because of the nature and characteristics of available sample, particularly, being professionals working at infrastructure related issues, again purposive/judgmental sampling method with full probability ('exhaustive' and/or 'saturated) of being included as a sample were used for the questionnaire survey. The researcher distributed questionnaire in person to the specified groups of personnel of two 'regulatory' institutions (Ministry of Urban and Infrastructure—MUI and Addis Ababa Construction Permit and Control Authority – AACPCA) because they have been also mandated to enhance the integration of member companies for development and effective functioning of infrastructure and hence urban/cities through their regulatory and coordination role.

The researcher first contacts the two companies before sampling to know the number of available sample groups. From the visiting, it was identified that from the whole personnel of the two institutions the subset of relevant sample group that mean engineering particularly, infrastructural related professionals were chosen and there were 12 professional and 14 professional of AACPCA and MUI respectively. Then the researcher decided to take equal number of samples from both group and accordingly, the maximum number available at AACPCA (12 professionals) was selected logically as the 'governing rule' to select number of

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

sample. Then with the intention of taking equal number of respondent from both sub-sets, equal (12 personnel) from each and totally 24 samples were selected to involve in the questionnaire survey.

As such, equal number—twelve (12) questionnaires were distributed to the available personnel/professionals working at infrastructural sector of MUI whose professions are directly related to infrastructural related issues. Another twelve(12) the same questionnaires also disseminated to the available professionals of infrastructural sector of Addis Ababa city Construction permit and control Authority whose profession also has direct relation with infrastructure and the problem under study.

The main reason why using this sampling method and taking the above mentioned as target population and/or main data source was that, they are the one available, mandated, most interrelated, responsible and concerned bodies for issues related to public infrastructures investment, administration and the problem understudy. All of the above discussed issues regarding data collection methods, target population, sampling methods, number of population and samples were summarized below as in table 3.1.

Table 3.1: Summary of sampling and data collection methods

No.	Data collection Method	Target population	Sampling method used	Number of population	Number of sample
1	Interview Survey	AACAUBGDB,AACRA, AAWSA,EEU and ETC	Non-probability-- judgmental or purposive	5 infrastructural Companies	5
2	Field observation and/or Case Study	Excavation being under taken in Addis Ababa City mainly at central region or zone of the city	Non-probability— judgmental or purposive	More than 50 excavation events	5 sites for case studies
3	Questionnaire Survey	Engineering and infrastructure related professionals of AACPCA and MUI	Non-probability— judgmental or purposive	12+12=24	24

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

4	Desk study/document review	Secondary data (literature, document of infrastructural repair work, video of panel discussion of ‘National integrated infrastructure committee’)	Non-probability— judgmental or purposive	More than 300 literatures/data source materials	132 cited & referenced
				Cost data of 5 excavation events	Cost data of the available 3
				1 video of panel discussion	1 video of panel discussion

Source: (author’s summary)

3.2.2 Data sources and collection Methods

As already set out earlier, the main objective of this research was to investigate the root causes and impacts of frequent excavations to existing infrastructures of Addis Ababa city in such a way to avoid and/or minimize the root causes and subsequent impacts, so as to contribute to good performance of infrastructure and the city at all. To achieve this goal, both secondary and primary through desk study and field research methods (Naoum, 2007) were employed.

3.2.2.1 Secondary data sources and collection

Desk study research method, under which secondary data were collected and analyzed, was undertaken. For this method, as secondary data , systematic review of relevant literatures was undertaken over relatively longer proportion of this research time from which the scholarly recognized causes and impacts of the problem under scrutiny (‘frequent excavations to the existing city infrastructure’ were identified as general to worldwide experiences. Video of panel discussion of member committee for National Integrated Infrastructure made on Fana TV through YouTube channel link obtained from ETC was also the other secondary data source of this research. Document of repairing or rework costs of city infrastructure at some selected case studies of excavation sites were obtained from AACRA’s road maintenance department, was also processed and analyzed as secondary data.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

To this end, different ‘web browsers’ and ‘search engines’ such as Google scholars, Science Hub and others were used to search and download materials and/or literatures related to this topic using key terms of the research. Then downloaded resources were checked or screened out for relevance and completeness, categorized and stored for detail review and appraisal.

3.2.2.2 Primary data sources and collection

As the name indicates, primary data (the original or firsthand) data were directly collected by the researcher through field work. Under this, data collection methods such as field observation and face-to-face interview were undertaken by the author this research.

Field observation to excavations undertaken to the existing roadways and sidewalks as well as underneath buried utilities within the Addis Ababa city was made. Different materials such as paper pen, pencil, checklist based questions, smart phone camera to capture photography and video of excavated infrastructure were used to collect on spot data. In addition to these, ‘Google Earth’ also used to indicate the overall locations of observed events.

By this method, excavations such as: pit excavation, trench excavations, mass or bulk excavations and cut or removal of pavements of both roadways and walkways were observed, captured by camera. As well as, data regarding causes and impacts of the excavations were obtained by interviewing peoples there (workers—supervisors, foreman, users—residents and business holders and passengers at the vicinity of excavations). Causes and impacts data deduced by the researcher were also noted, recorded and stored until analysis.

In-depth casa study of some selected sites among field observed excavations to the existing infrastructures were also undertaken. Moreover regarding these selected cases, the extraction of data from documents and interview responses as well as observation were done. Face-to-face interview with professionals of purposely selected infrastructural sectors were undertaken. For this method, semi-structured type of interview (Appendix B2) was employed to drive information from the interviewees.

3.2 Data Analysis techniques and tools

3.3.1 Qualitative analysis

For this research, both qualitative and quantitative but, dominantly qualitative analysis approach was involved. To analyze qualitative data, thematic analysis (TA) particularly for interview and content analysis (CA) for documents obtained from respondents and/or stakeholders as well as narrative method for data collected by field observation particularly, by pictures and/or photographs were undertaken. According to some authors (Bennett and Gough, 2013; Niland et al., 2014; Neville et al., 2015) cited by Appleton(1995), content analysis and thematic analysis are best ways of analyzing qualitative data gathered through face-to-face data collecting methods such as focus group discussion, online discussion, interview with open-ended questions. In this research, content analysis and thematic analysis methods were employed to analyze qualitative data collected from relevant documents and by face-to-face particularly, semi-structured type of interview undertaken with the infrastructural sectors respectively. This method in turn involved several steps/processes:

Coding and Summarizing of data: qualitative data particularly, perceptions, experiences and practices of subjects obtained by recording and taking notes were listed repeatedly and transcribed ,as well as categorized thematically under several categories of ideas (Naoum, 2007). Coded data then summarized in to final form of being ready and then analyzed as in chapter four of this research—analysis portion.

3.3.2 Quantitative analysis

Both descriptive and inferential statistics were used to analyze the quantitative portion of the data collected by questionnaire survey for which mean score and/or average ranking difference measurement was used. Questionnaire survey data was analyzed by descriptive statistics particularly, ‘frequency distribution’, measurement of central tendency and inferential statistics particularly, Spearman’s correlation measurement respectively. Larger portion of the questionnaire responses/data were analyzed by, descriptive analyses, particularly, frequency distribution, ratio and /or proportion and measurement of central tendency such as, mean/average, and mode of the data set in which tables and charts were employed.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Inferential test for non-parametric, specifically, Spearman (rho) correlation measuring (Naoum, 2007) was also used to measure the perception and/or thinking of respondents from the two selected/ targeted groups regarding the proposed indicators of human actions as root causes of FEECI. As such, how the listed indicators of human actions as root causes of frequent excavation to existing infrastructure of Addis Ababa were perceived and ranked by professionals working at infrastructure related departments/sectors of both Ministry of Urban and Infrastructure(MUI) and Addis Ababa Construction Permit and Control Authority —(AACPCA) was measured using the following formula:

$$\rho = 1 - \frac{6 \sum di^2}{N(N^2 - 1)} \text{ ----- 3.1}$$

where, ρ = rho spearman's correlation measuring coefficient, di = the difference in ranking between the two groups and N = number of items or factors. Spearman correlation coefficient in this research was selected by the author because the data fulfill the criteria rationales listed by Naoum (2007) to choose it are:(1)The data are respondents' attitude/perception, particularly agreement/disagreement, rating and ranking that need to be measured on ordinal Likert scale ;(2) Spearman correlation coefficient measurement fits with any data than other tools such as Pearson correlation which mandatorily require fulfillment of specific criteria, for example normality of data distribution. Moreover, Crombach's alpha to check the reliability or internal consistency between the items or indicators and Relative importance index (RII) to determine the relative importance of the indicators were calculated.

Among available analysis tools, excel (spread sheet and Add-ins) was mainly used for analysis of data in both descriptive and inferential parts of this research. In addition to this, statistical table was also utilized.

CHAPTER FOUR: DATA ANALYSIS AND RESULT DISCUSSION

4.1 Introduction

In this chapter data collected from field observation and/or in-depth cases study, interview survey, questionnaire survey and secondary data of records were analyzed. The results obtained from each method were triangulated in the discussion section to enhance the validity of the result and/or the finding of the research.

4.2 Qualitative analysis

This is the main section and method among the analysis techniques used in this research because it is where the data collected via face-to-face and in depth interview hence expected to be rich, reliable were analyzed. However, it was the most time consuming both to collect and analyze data than the other employed methods.

In interview data collection method of this new research, both federal and Addis Ababa city Administration infrastructure related companies such as AACAUFGDB, AACRA, AAWSA, EEU and ETC were involved. Semi-structured type of interview was used to ask and drive information from the respondents using the advantage of semi-structured type of interview which has the mixed characteristics and advantages of both structured and unstructured types. Although the prepared written questions were the same and/or common to all of these companies, the responses were more concerned to the corresponding company and general to some extent.

What make the interview ‘semi-structured type’ and responses of each company and their departments unique for this research were , the additional unwritten/oral questions asked meanwhile following the tangible conversation and response of a particular participant to the written questions. The researcher requested all of these companies for their cooperation and participation in this research, by the letter written by Civil and Environmental Engineering department of Addis Ababa institute of technology (AAiT) as well as the one written by the author as cover of the prepared questions(see appendix B2).

Accordingly, the companies registered the letter, accepted and directed to their specific departments and/or sectors those were thought correspondent and more relevant respondent to the questions. In addition, some of the companies particularly, Ethio-telecom let the author to

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

sign the protocol or consent for the sake of confidentiality of the data before responding to the research interview questions and giving relevant secondary data/documents.

On the other hand, to obey the research ethics, the author also told/informed the respondents that the interview would be recorded for later transcription for which most of them were willing but few of them. Accordingly, interview responses of those who were willing for such method were recorded by smart phone with note taking. Only note taking were done for responses of those who were not willing for recording.

Data collected in such a way were coded and categorized as follows in table 4.1 and the contents of each interview was then qualitatively analyzed under the coded themes.

Table 4:1: Codes and categories of interview data of corresponding respondents

No.	Participant infrastructural company	Relevant participant department/sector of the company	Thematic codes and/or Categories of data/responses
1	AACAU BGDB	Urban Beautification directorate	<p>1. <i>Availability/noticeability of frequent excavations/rework:</i> excavations “at Goro square”, “at Koye Fecce square”, “at Churchill street walkway”</p> <p>2. <i>Subsequent impacts:</i> falling of children and intoxicated person in excavated hole, injury, bad smell due to gray water flowing over surface, health problem related to such wastes, poor profile /appearance of the city ,cost of reconstruction and beautification, monthly payment due MSEs for greenery and beautification works,”</p> <p>3. <i>Root causes of frequent excavations/reworks :</i> “lack of integration among and coordination infrastructure companies, poorly qualified persons at high positions hence inapplicability of the principle ‘the right person at the right position’ , hidden corrupted actions (even at family level, religious institution, government institution) poor culture and negative attitude of community, particularly at commercial area such as Merkato and autobus tera towards development of best infrastructure and beautification of city, actions of some individuals deliberately damaging new infrastructure”</p> <p>4. <i>Suggestion for guidelines on infrastructure</i></p>

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

			<i>related issues:</i> reconstruction of the slummed areas of the city
2	AACRA	Road Asset Administration & Database Directorate	<p>1. <i>Availability/noticeability of frequent excavations/rework:</i> “yes unquestionably, but reduced because of started integration of infrastructural companies, the road segment at piazza to patriot square, Churchill street, at National theater near the old building of ECB head quarter etc.”</p> <p>2. <i>Subsequent impacts:</i> “rough, irregular roadways, sidewalks, injury to users for example pregnant women fallen in to uncovered hole excavated for manhole, death of person fallen in manhole newly being constructed street or road segment between Bole Mechael and Bole Bulbula around airport, traffic congestion cost, service interruptions, reconstruction costs”</p> <p>3. <i>Root causes of frequent excavations/reworks:</i> “technical—workmanship, negligence use of materials for example temperature of AC mix, poor planning and designing of drainage system, emergent rather than scientific method of maintenance, corruption—misuse of resources and giving priority for politically intended purposes and areas than scheduled construction, maintenance or repairing of infrastructure, enforcement of co-installation of utility lines at illegally permitted under standard utility corridor at some areas in the city, Bad culture of community in using and handling infrastructure—damping solid wastes such as dead body of animals, residue of used products, concrete , plastics etc.in drainage systems”</p> <p>4. <i>Suggestion for guidelines on infrastructure related issues :</i></p>
		Road Maintenance Project Management Team	

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

3	AAWSA	At sewerage sector Construction Supervision & Contract Administration Sub-Process	<p>1. <i>Availability/noticeability of frequent excavations/rework</i>: “Yes of course, yes there are, but the excavation is mandatory to upgrade the services”</p> <p>2. <i>Subsequent impacts</i>: “Car accident—fallen in excavated trench, damage and interruption of utility services—power outage resulting into bursting of water mains due to pressure in vacuum of the pipes, high cost of using diesels for additional pumping of water up the elevated areas of the city to supply water, construction costs”</p> <p>3. <i>Root causes of frequent excavations/reworks</i>: increment of demand due to population growth as a result of immigration to city, unplanned establishment and the need for reconstruction of the Addis Ababa, absence of utility corridor, poverty and hence separate budgeting of the infrastructural , company, hidden corruption actions , poor technical practices—workmanship during excavations damaging utility and poor installation, poor reinstatement of excavated or cut roadway or walkway, ups and downs nature of topography of the city etc., political sudden involvement to work new, to relocate, improve existing utility ”</p> <p>4. <i>Suggestion for guidelines on infrastructure related issues</i>:</p>
		At potable water supply sector Main line Laying and Maintenance for Condominium and other Infrastructure Sub-process	
		At potable Water Heavy line Installation and Maintenance Case Team	
4	EEU	Infrastructural Integration Focal person	<p>1. <i>Availability/noticeability of frequent excavations/rework</i>: “there are</p> <p>2. <i>Subsequent impacts</i>: “utility damage, services and hence business income interruption, construction cost”</p> <p>3. <i>Root causes of frequent excavations/reworks</i>: different source and schedule of budget to different utility companies, poverty or limited resource of the country and the city, however the community did not understand such problem rather blame the companies, originally unplanned development of the city</p> <p>4. <i>Suggestion for guidelines on infrastructure related issues</i>:</p>

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

5	ETC	External Coordination Section	<p>1. <i>Availability/noticeability of frequent excavations/rework</i>: tangibly noticed, for example undertaken more than three times at walkway of Churchill Avenue, being occurring along the street where ‘Berhanina Selam matemia dirigit’ meaning at the printing press called as above.</p> <p>2. <i>Subsequent impacts</i>: non attractive image of the city looking like webs of spider, rough and inconvenient roads walkways, flooded surface of street, bad odors due to broken and up flowing gray water or illegally, damage of utility assets hence interrupted services, economic losses due to</p> <p>3. <i>Root causes of frequent excavations/reworks</i> :political interference and leverage for instance, the initiation of widening Churchill Avenue and installation of CCTV camera have relation with the then upcoming national election though they are basically important ,lack of integration among infrastructural stakeholders, natural forces such as land sliding, flood, man-induced factors, and thirdly deterioration aging of the infrastructure</p> <p>4. <i>Suggestion for guidelines on infrastructure related issues</i>:</p>
---	-----	-------------------------------	---

Source: Author’s summary of interview survey

4.2.1 Analysis of data obtained interviewing respondent from AACAU BGDB

1. Availability /noticeability of frequent excavations/rework in Addis Ababa: According to the view of respondent from this department, although excavation is mandatory to upgrade the available services of infrastructure, there have been seen frequent and arbitrary excavations to existing infrastructure of Addis Ababa city.

Among the excavations he noticed, the respondent referred excavation events undertaken at “Goro round square” and at “Walkway of the road known as Churchill Avenue” as example that could be avoidable but repeatedly undertaken there. The excavations and/or repeated earth works in general were undertaken by those available and commonly known federal and regional/city’s companies mandated to develop and manage the physical infrastructures and their services.

The infrastructural companies were ranked as high to low frequent executer, based on the frequency or repetition of undertaking excavations and/or rework to the existing city

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

infrastructure. Accordingly, the respondents ranked ETC as the most frequently undertaking reworks, AACRA as the Second, AAWSA as the third, EEU as the fourth and AACAU BGDB—respondent’s home company as the least frequent undertaker of earth works and or infrastructural rework. The respondent stated that there are different departments/sectors of AACAU BGDB who work with each other internally and externally with sub-cities, woreda and assigned micro and small enterprises (MSEs) for which job opportunity of developing urban greenery is periodically given by the city Administration.

The respondent also further stated that there are chances of reworks of particularly, earth works—excavation and removal of materials or soils that are not suitable for plants and substitution of them by the suitable one from other sources as well as plantations. As such, the respondent articulated that there were the events of excavations and removal of the unsuitable soil supplied by the MSEs investigated during supervision of the works particularly at “Koye Facce square”.

2. Subsequent impacts: The response of the interviewee indicates that there are subsequent impacts related to health and safety of users and workers, aesthetic (cleanness, being green and beauty of) as well as economy of the city.

According to the respondent, the bad smell or odor of sewerage wastes flowed or detained in open spaces or to surfaces has been affecting the health of both users and workers, repeatedly excavated and left open/un covered pits and/or trenches on the other hand, are the dangerous accidents to passengers who may fall into it and inconvenient for movement of users of both the roadway—motorists and walkways—pedestrians. The respondent further disclosed that unit price of the greenery and/or beautification of the city is 15.77Birr/1m² hence costs the company and/or the city, 78,850 Birr/m² before VAT and 90,677 with 50/100 Birr/m² after VAT monthly payment due the MSEs. As such, there could be economic impacts as reworks are seen being undertaken as in the case of above mentioned example.

3. Root causes of frequent excavations/reworks : The data from this interviewee shows that there are root causes such as: ‘Lack of good cooperation and/or coordination among infrastructure companies’, ‘Poorly qualified, with no or low experience workers and/or professionals below the requirements but miss assigned at high positions and thus, negatively affecting the quality of

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

works and/or implementation eventually resulting in to early and frequent failures of the infrastructure and hence rework’, ‘Lack of study before decision making and implementation’, ‘Absence of plan led development of the city from the origin and hence slummed area and unpleasant appearance of infrastructures and/or the city for example the overpassing light rail way of the city’ , ‘Lack of zonal/functional and aesthetical planning of the city areas for instance division into recreational-greenery which according to the requirement should be developed as per the 20/50 % by private and public respectively, commercial and etc.’, ‘Bad culture and attitude of the community to wards development of new and aesthetical infrastructure specially’, according to him those who ‘highly stacked’ to the commercial and/or economic advantages (income from passengers’ bed room rental and the like) of the specific area such as community around ‘Autobus Tera’ and largest market place such as ‘Merkato’, theft and deliberate damaging of existing and newly developed infrastructures” and (7) Corrupted human actions at different social and religious classes: The respondent

“In our country Ethiopia, corruptions are not only committed in governmental institutions and/or sectors, but also in family, and even in religious institutions!...for instance the road whose construction cost was reported to be 20 million Birr per Kilometer was failed immediately after construction”(The interviewee from AACaubGDB)

4. Suggestion for guidelines on infrastructure related issues: Suggestion of this respondent will be presented under section 4.6 as a part of developed base guide line to use in development of common guidelines for infrastructural works.

4.2.2 Analysis of data obtained interviewing respondents from AACRA

Regarding this, the respondents stated that frequency of excavation is being reduced relatively; this is because the integration and communication between the infrastructure sectors are modified a little bit than ever former times. However, it is ‘unquestionable’, that still there are frequent excavations to the existing infrastructures of Addis Ababa city, according to the interviewees.

The known infrastructural sectors were ranked by these respondents also, from the one most frequently undertaking infrastructural repairing and hence rework to that rarely undertakes

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

excavations. Accordingly, ETC, AAWSA, EEU, AACRA and AACAUDBGDB were ranked as first, second, third, fourth and fifth undertaker of frequent excavations respectively.

The interviewee stated that there are different reasons why frequent excavations undertaken to existing infrastructure of Addis Ababa city. According to the respondents, the causes include the following: installation of more utility lines in common line at narrower utility corridor which is inappropriate, the need to change the capacity, function or direction/location of existing infrastructure, poor workmanship (for example, machine operators works as they want rather than as the requirement and supervision of professionals, temperature of asphalt concrete mix from batching plant to pavement time and ignorance of such deviation by all workers even by professionals, the maintenance action based on emergency rather than investigating the real and root causes of failure and appropriate solution, political involvement of higher government officials changing the planning and scheduling(giving priorities of resource allocation for maintenance and construction of politically initiated projects and areas for example, the machineries of AACRA are working at the so called ‘Ye chaka project’ meaning ‘The forest project’—the newly being constructed national palace),corruption action of stakeholders particularly managers and workers of AACRA during maintenance and other stages, culture of infrastructural misusing of community—damping solid wastes in drainage system etc. The response of the interviewee clearly shows that intentional (corrupted) and unintentional (error) actions of human (stakeholders) through technical, political and cultural practices regarding infrastructure are the root causes of such frequent excavations to the existing infrastructure of Addis Ababa.

4.2.3 Analysis of data obtained interviewing respondents from AAWSA

1. Availability or noticeability of frequent excavations/rework: Face-to-face interview also held with three of the professionals working at AAWSA: one at ‘Heavy line water distribution department’, one at ‘Sewerage sector construction supervision & contract administration sub-process’ and the other one at “Potable water supply sector main line laying and maintenance for condominium and other infrastructure sub-process” separately. Like others, these respondents also acknowledged the occurrence of frequent excavations or infrastructural reworks within the city,

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Addis Ababa. These respondents also ranked the infrastructural companies in terms of the frequency they execute excavation works to existing infrastructure of the city, Addis Ababa.

However one of this interviewees—the one from ‘Potable water supply sector of main line laying and maintenance for condominium and other infrastructure sub-process’ said that though the excavations seen within the city here and there, he do not consider as repeated event rather as mandatorily undertaken to upgrade the capacity of the existing infrastructure to meet the rapidly growing demand with population growth due to rural to city immigration which in turn also related to political, economic and social problems.

2. Occurrence of subsequent impacts: regarding impacts, all of them acknowledged that the FEECI in Addis Ababa has been imposing several (aesthetical, safety & economical) impacts. They exemplified the accidental falling of vehicle in to excavated trench, loss of income for business firms due to inaccessible centers in the vicinity of excavation activities, direct construction costs, relocation costs, etc. The first interviewee agreed that the frequent excavations or reworks of existing infrastructure of the city have impacts. According to him, there are the cases when the third party particularly AACRA is not correctly, even never reinstate the excavated or cut roads especially the interior or tertiary roads that are not in the attention of public though AAWSA pay them repairing/reinstatement cost calculated/estimated for each type of the roads. Those cut and/or excavated roadways or walkways left as it is and bad looks that decrease the aesthetics of the locality and hence the city as well and results in inconveniency to the users of street and accordingly that is why community blame AAWSA and other utility companies.

3. Root causes of frequent excavations/reworks: one of respondents stated that the causes of frequent excavations in the city is to maintain or repair the frequently damaged pipes and water distribution systems of the city. The interviewee also listed factors causing damaging water system leading to such frequent reworks to be: (a) air pressure occurred in vacuumed portion of the pipe and sudden over pumped water following outage and emerging of electric power;(b)strike damage occurred during excavation by AACRA operators according to him “who are negligent” despite the effort made by assigning supervisor and presence of the warning sign installed along the pipes to prevent damage of the system ; (c) failure of the potable water system due to poor installation particularly, leakage at joints where socket and spigot were loosely connected and also damage of pipe systems buried at shallow depth than the standard.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

This in turns according to him, also happen due to workmanship installing the pipe system. The interview further stated that the nature or topography of Addis Ababa city is one of the root causes for FEECI. According to him, this especially, the upward movement of both potable and gray water Administered by AAWSA and storm water by AACRA in all cases in which failures of the systems either physically or functionally occurred frequently relative to other utilities.

In general, the interview data from these interviewees(of mentioned companies) implies that root causes of FEECI in Addis Ababa are intentional(corrupted) and un intentional(erroneous) human actions which accordingly, can further be manifested in terms of technical (spontaneous establishment and sprawl development of Addis Ababa, poor planning, designing, lack of sufficient utility corridor to accommodate all, scheduling/integration of infrastructural works, poor construction, reinstatement of excavated road or walkways etc.),political (sudden order of some infrastructural works: for example ‘relocation of water main for construction of a statue representing Washington DC to express its relationship with Addis Ababa,) and cultural/behavioral(dumping solid wastes, by products of killed animals during holidays, dumping construction material on road ways and walkways) practices regarding infrastructure.

4. Suggestion for guidelines on infrastructure related issues: was presented in section 4.6 of the research where it was used being some part of the guidelines developed.

4.2.4 Analysis of data obtained interviewing respondents from EEU

From this company, two professionals were interviewed: one was from Planning Directorate and the other was focal person for integrated infrastructure member committee. The one from the planning directorate responded shortly and generally after hearing general content of the interview questions.

Acknowledging the noticeability of FEECI just like other respondents, he responded that the root cause of frequent excavations is the poverty. According to him, sources and allocation schedule of budget or fund of these different infrastructures are different and hence they always enforced to undertake their own works as per their schedule even though there is an effort of working in integration to minimize such problems. Although the findings of the previous researchers (Gebreegziabher,2014;Ghiday,2023) was this–different source and schedule of budget for each companies, the notion of “*poverty*” by the respondent from planning directorate and/or

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

“Limited resource of the country” by others respondents was one of root cause of FECCI as *one new finding of this research.*

This is because it was identified scientifically though it was already known as the inhibitor of the developed and improved life standard of the citizens. Furthermore, the respondent also agreed that human actions in terms of technical, political and cultural/behavioral are also root causes of early and frequent failure and hence FECCI which in turn imposes impacts particularly, on economy of the country. The other interviewee from this company also agreed and responded almost similar to the former respondent.

4.2.5 Analysis of data obtained interviewing respondent from ETC

The researcher also made a face-to-face interview with the manager of ‘External Coordination Section’ of ETC who was also the committee member of the ‘Integrated Infrastructural Works’ that is coordinated by “National Infrastructure Integration” of MUI which originally(before being merged as the present MUI) was known as Federal Integrated Infrastructure Development and Coordination Agency(FIIDCA).In addition to responses and/or deep discussion, this respondent also shared the secondary data (video of panel discussion made by coordinator and member committee came from MUI and other sectors : ERA, EEU and ETC in cooperation with FanaTv).The document (video) also presented online with link, (<https://youtu.be/LhwtykfQjVA?si=LJMIX-GDdfCz-SHv>) titled ‘Cities and infrastructure day’. Data collected in such ways were coded as in table 4.1 and analyzed in conjunction to that obtained from the other interviewees as follows:

1. Availability or noticeability of frequent excavations/rework: The respondent acknowledged that there are frequent excavations and/or reworks to existing infrastructure of the city, Addis Ababa and hence failure (damage of infrastructures — street components and utilities) or vice versa. He further elaborated this by referring the frequent (according to him occurred more than three times) excavation (1) to expand—to make boulevard the street known as ‘Churchill street’ (for ‘political exploitation’– to be voted and win the then election). This site is one of the investigated excavation events as a particular case study among identified excavations/reworks during field observation of the researcher.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

According to the interviewee, AACRA was forced by the commands directly given by higher officials of the municipality to widen the referred street without preparing common design and/or revision or modification of the existing infrastructure which eventually resulted in repeated excavations. (2) Excavation to widen the road segment along ‘Brhaninna Selam’ printing Press at which utility line of ETC was poorly installed underneath curbstone and hence paused for a time being requiring decision and then rework.

Being asked to rank the known infrastructural companies in their frequency order of undertaking infrastructural repair works and/or excavations, the interviewee acknowledged that all of the companies frequently undertake excavations or reworks to existing infrastructure and tried to roughly rank as AACRA,ETC,AAWSA as the most frequent ,second and third frequently undertaking excavation or repair work respectively and further commented to include EEP(Ethiopian Electric Power) which according to him also a member of integration.

2. Occurrence of subsequent impacts: This respondent agreed that such frequent excavations and/or reworks of the existing city infrastructure impose health and safety, aesthetics and economic impacts in general. He also elaborated those impacts as follows: (1) regarding health and safety, he stated that because our communities’ awareness and culture of environmental sanitation is not good, toilet and/or latrine contaminated runoff come up and flow over the surface particularly on the roads as open ditches and sewer lines are frequently failed (damaged and blocked or clogged by solid wastes) to safely and properly convey and discharge the contaminated runoff.

Accordingly, exposure of individual and/or community to such contaminated runoff and dust remained on road surface after runoff, imposes health impact. He further revealed that the accident of run off especially along and at lower area of sloppy topography according to him, for example, like the Churchill street, has risk of being taken away by runoff in which every time it rains the community and passengers there are suffering from is one of the safety impacts of the frequently and poorly executed work of the street; (2) aesthetic and related impact — the respondent explained that the appearance of the city is not good due to the muddy as well as dusty conditions following repeated excavations or reworks and flood or run off.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

He also expressed the appearance of the city, Addis Ababa, as “spider web—disorderly and overhanged installations of different utility lines,” though according to him the city is expected and/or proposed to be ‘Smart city’.(3) economic and sustainability impacts—the interviewee stated that this and related impact is not only on individuals but it is also imposed on the public or a country according to him that is because most of materials for example, that of telecom utility and/or service provision are purchased by foreign currency to mandatorily sustain the ever increasingly expected services of telecom including the recently being digitalized one whose application or utilization is rapidly increasing.

He further explained that due to frequent excavations and/or damages, there will be the impacts of business and/or transactions loss on customers or end users of telecom services which in general affects economy.

3. Root causes of frequent excavations/reworks: regarding this, the respondent said “Absence or lack of appropriate utility corridor within the city is the root cause of frequent excavations”. According to him, implementation or how to construct is also the other root because, for example when interior cobble stone roads are constructed, the implementers do not consider corridor through which utilities should be installed, they simply construct from one side to the other.

“There is no integration and coordination as well as common plan and design shared by all mandatory stakeholders from the very beginning or conception of the infrastructure...”.(Interviewee from ETC)

This respondent explained in depth that the root causes of FEECI are the political influence and interference of higher officials/politician and their intimates as most of the times, they enforce infrastructural companies and professionals to execute infrastructural works urgently without or with insufficient feasibility study, holistic and/or complete plan and design of interrelated infrastructure only think what they intended to political achievement which is the common root cause in Addis Ababa and/or the country, Ethiopia at all.

According to the interviewee, lack of master plan implementation, absence of coordination or integration of stakeholders, lack of common understanding and feeling as well as absence of inclusive participation in planning and design from the conception of the infrastructural projects

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

are other root causes of the frequent excavations to the existing infrastructure of Addis Ababa city.

Further identifying causes of infrastructure failure as natural phenomena (land slide, flood or runoff and falling tree branches or trunks) ,man-induced failures and self-damaged that means due to age of the infrastructure, he stated that the man-induced failures are due to carelessness action of human. For example, damaging existing infrastructure in the vicinity of construction activities is one of these types. Although the respondent abstain himself to reveal the presence of tangible corrupted actions as a root cause for such early and frequent failure and hence frequent excavations to existing infrastructure, he stated that though corruption is hidden, he believe as it can be a root cause for such repeated failure and hence frequent excavations or vice versa.

4. Respondents’ Suggestion for guidelines on infrastructure related issues: the respondent replied being asked by the researcher to do so forwarding suggestions that was taken and presented as one part of the developed guideline in section 4.7 of this research by which the fourth objective and seventh question of the research were achieved and answered respectively that are concerned with developing tool and/or common guidelines for infrastructure stake holders.

Respondents were asked to rank infrastructure companies in first, second...fifth from the most frequently executing excavations and/or infrastructural rework as per their (respondents’) experience and judgments on the companies’ attributions. Accordingly, the respondents ranked the companies attribution to frequent excavations as in table 4.2 below.

Table 4.2: Rank or attribution of infrastructural companies to frequent excavation in the city

Respondents(Ri)	Rank of infrastructural companies given by Respondent in Frequency order of their execution of excavation (1 st ,2 nd ...n th from most frequently excavating/reworking to lowest)					
	AACAUBGDB	AACRA	AAWSA	EEU	ETC	Others
R1	5 th	2 nd	3 rd	4 th	1 st	
R2	5 th	4 th	2 nd	3 rd	1 st	
R3	5 th	1 st	4 th	2 nd	3 rd	
R4	6 th	1 st	3 rd	4 th	2 nd	5 th (AATM)
R5	5 th	4 th	2 nd	3 rd	1 st	

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

R6	5 th	2 nd	1 st	3 rd	4 th	
R7	*	1 st	*	2 nd	3 rd	
Mode(s)	5 th	1 st	2 nd & 3 rd	3 rd	1 st	

Source: Authors analysis of interview survey

Table 4.2 indicates that the rank of mentioned infrastructural companies in attribution to FEECI from the most frequently undertaking excavations or infrastructural reworks on existing infrastructures of Addis Ababa city. The researcher analyzed data obtained from interviewees as in the table using mode(s)—the most frequently recorded or given responses by each respondents regarding each companies.

Accordingly, it was found that AACRA and ETC were ranked as the most frequently undertaking excavations having equal mode = 1st, AAWSA the second, having two modes but because the mode of EEU was recorded to be third, thus, automatically it was rationale to rank AAWSA as the second most, EEU the third most, and AACAUBGDB as the fifth or rarely undertaking excavations to existing city infrastructure of Addis Ababa. This answered the question that inquiry rank or attribution of the noticed frequent excavations in the city.

The mark * in table 4.2 was used to remind that respondent (R7) on the corresponding row did not rank AACAUBGDB and AAWSA. On the other hand, one of the respondents (R4) included and ranked 5th, AATM—Addis Ababa Traffic Management though, it did not formerly included as one of the participants.

4.3 Analysis of data collected by field observations

As mentioned in chapter three, the methodology, field observation was one of the employed data collection methods and undertaken before, during and after the other methods of this research. Figure 4.1: through figure 4. 11: depicts locations and situations of several excavation events and/or damages as well as subsequent impacts among observed excavation sites undertaken within the city, Addis Ababa during field observation data collection.

Excavations observed undertaken and/or being undertaken within Addis Ababa city during data collection for this research include: cutting of asphalt and removal of coble stone paved road

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

surfaces, trench excavations to walkways, roadways, mass or bulk excavation to entire roadway within right of way, minor pit excavations and so on.



Fig.4.1: Observed excavations within Addis Ababa city located on Google Earth (by author on 28/8/2023)

Figure 4.1 indicates general distribution patterns or layouts of observed excavation events to the possibly nearest locations within Addis Ababa city just to indicate on 'Google earth'.

Although both the excavations undertaken or being undertaken as well as observed were not only those indicated in the figure, more than fifty events were observed, it was intended just to show the general distribution pattern of excavations to existing infrastructure within the city. In addition to figure 4.1, photographs of those excavations events captured by smart phone during field observation and real top or street view again from Google earth including those used in case study part were presented in the following figures .

However, what should be noted here is (except those illustrated below) that, all of those pictures captured by the researcher during data collection were not included both in body of the research and the appendix because of the more space it requires to accommodate all in this pages of the paper. The following pictures and other included were only selected just to illustrate the descriptions of those frequent excavations on existing infrastructures of Addis Ababa city.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets



(a) Previously excavated walkway (b) trenching twice within week (c) poor installation and reinstating of the trench



(d) Constructed curb stone and poorly reinstated excavated walkway (e) Repeated trenching and inconvenience to users

Fig.4.2: Repeated trench excavations to walkways of Adwa street (Captured by author from 28/6/2023 onward)

As can be seen, fig.4.2 illustrated five component pictures of street works (trench excavations, uninstillation of utility pipes, construction of curb stone). The excavation event was being undertaken to both side walkways of the road segment between Piasa and Patriots' square road segment called as "Adwa street". The above figure however, indicates only the exact location of excavation executed just near the priots's quare, on the right side of the lane when traveling from the square to piasa.

Figure 4.2 (a) clearly indicates that there was previously undertaken excavation to the walkway there, as the cutting line and rough surface of the walkway evidently illustrates. On the other hand, excavations illustrated in figure 4.2 (b), (c), (d) and (e) were observed being undertaken since recently, from 28/062023 G.C on ward all at different time indicating who much repetitive the action was. The researcher observed and interviewed one of the worker particularly,

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Construction foremen of AACRA. According to the foreman, purpose street work was widening of the roadway and walkways of the existing street. That was also to upgrade the capacity and functions of the street to have wide lanes and/or boulevard to accommodate amenities, make it user friendly for cycling and pedestrian as per the goal of new master plan and/or redevelopment. Particularly, the excavations were executed to install PVC pipes for telecom utility lines by ETC and to construct curb stone by AACRA. From this, it can be said while expansion/upgrading is the immediate cause; the obsolescence (in this case under capacity and standard to the contemporary demand) of the road can be said the intermediate cause for such street works.

The field observation of the situation, the interview with the above mentioned foreman during the observation as well as the response of interviewee from ETC in which he referred the situation as one of an example of frequent excavations undertaken due to lack of integration between different companies, particularly ETC and AACRA and incompetence of manpower working there, the excavation event was undertaken twice within unreasonable time one for ETC and the other for AACRA work schedule and purpose. The interviewee further stated that the work was not correctly done yet bringing conflict between the stakeholders, which also need decision and may also need further excavations.

According to the interviewee who was from ETC, although the subcontractor MSE assigned there to undertake works contracting with AACRA, it also allowed to perform the work expected to be done by ETC with the intention of minimizing such conflicts, reworks and damages that may happen when the work executed by different bodies; AACRA's professional working at the site wrongly constructed the curb stone along utility pipe exactly lines installed for the purpose of services given by ETC. The analysis indicates that the causes of rework or frequent excavation in this particular case are:

1. Lack of robust feasibility study and/or planning of mentioned road segment which limited the capacity and function of the roadway and walkways not matching with the current demand which in turn also due to poor forecasting either due to lack of information, skill, experience, knowledge or limited recourse for construction of the road considering future demand or combination of all factors as the root causes though in fact the street was planned and constructed before many years and served long-lasting up to date,

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

2. Lack of integration, planning and scheduling as well as clear and complete documents particularly, utility maps among the companies,
3. Lack of skill and knowledge, professionalism of manpower working there—poor and negligent supervision, as also said by the interviewee from ETC.



(a) Vehicles, pedestrians & workers at risky condition

(b) inconvenient travel of Mother backing child & other pedestrian

Fig.4.3: Excavation of entire road & walkways at “Labu” (Captured by author)

The above figure is a photograph of mass excavation undertaken at Lafto sub-city particularly at the area uniquely called “Labu”. The excavation was Mass or bulk excavation was undertaken to entire roadway and walkway within ROW of the road segment between the so called “Germen” and “Lafto” squares connecting to the expressway. According to information disseminated via media before several years and the field observation, the immediate cause of the excavation at this and other several areas such as the “ring road” segment from Bole sub-city Administration located at “Megenagna” bypassing Bole International airport to Kality Drivers training center square was to upgrade the capacity and function of the roads, mainly the roundabouts seen to be incapable to function accommodating the contemporary traffic.

Regarding this, it was announced via national Media that more than seven (7) squares or roundabouts of the above mentioned ring roads were going to be removed and/or replaced by

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

overpassing bridges or leveled without roundabout. Accordingly, the intention was to avoid or minimize the frequently happened and reported traffic accidents there due to the repeated traffic congestion and inconvenience at the squares. The excavation site and event illustrated in figure 4.3 above was one of the seven roundabouts announced to be removed and it has been undertaken to construct overpass bridge instead of removed roundabout and constructing the road wider than the existing to accommodate the ever increasing volume thereby avoiding the congestion and accident in the vicinities.

Although the road and its squares served over several years,— expected to serve longer than this, it is obvious that there was poor planning (poor forecasting) of the then future or today's demand or volume of traffic and/or the capacity as well as function of the roads and poor designing of their components. These in turn attribute to the intentional (corrupted action either as sudden initiation of the projects by the then politicians for their political leverage or diversion of the resource particularly budget allocated or should be allocated for other purpose such as private advantages) and/or unintentional (technical inability particularly forecasting of the volume and capacity as well as function) human—infrastructure stake holders actions and/or decisions especially during planning stage.

This in general indicates that the root cause of the excavations at the mentioned or illustrated locations of the ring road segments such as “Megenagna” to Kality was human technical and political actions during the planning stages.

Trench excavation to walkway of existing road near development bank of Ethiopia (DBE) the so-called *Tito Street* was also one of those captured during field observation and illustrated below as in fig.4.4.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets



(a) Muddy & inconvenient excavated sidewalk (b) poorly reinstated side walk enforce pedestrians to accidentally share roadway with vehicles



(c) Exposed and damaged utility lines

Fig.4.4: Trench excavation to walkway near DBE head quarter (Captured by author on 12/8/2023)

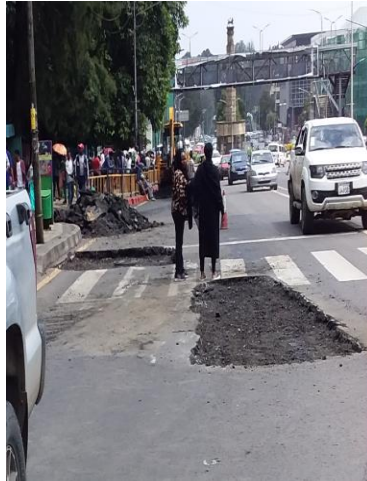
The field observation inference indicates that the immediate cause of the excavation was also to upgrade the capacity and function of the street just like that of “Adwa street” fig.4.2. Particularly, trench was excavated to install fiber optics for CCTV camera. This also the initiative of higher government officials as part of the redevelopment to improve the service particularly security within the city which though important but more focussed the political point of view than other technical and economical. Moreover, pictures of the event indicate that the reinstatement was poorly undertaken and pedestrian using the walkway were walking inconveniently and some of them were about to share the roadway with motorists (which in turns

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

could expose them to accident) due to the inconvenience of the excavated walkway. The observation and/or particularly, fig.4.4 (c) further indicates that, there was the nearly missed damage of existing utility line.



(a) Excavation to asphalt



(b) Asphalt cut at Zebra



(c) Repair work around manhole



(d) Removal of damaged surface course due to ingressed water



(e) Poorly constructed manhole

Fig .4.5 Cutting /excavating asphalt road in front of AAUCNCS (Captured by author 3/9/2023)

The road running from the Sidist kilo Yekatit 12 square which also known as King George VI street, main campus of Addis Ababa University, Addis Ababa University Institute of Technology (AAiT), which also bypasses Addis Ababa University Natural and Computational science campus (AAUCNCS) just before reaching “patriots’ square”, to National palace and so on is one of the main roads of Addis Ababa city. Field observation revealed that there were repeated street works which include widening of the road to some extent ,resurfacing of roadway and walkways

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

pavement and cutting and/or trenching through the walkways as well as part of asphalt at some locations previous time. Figure 4.5 in general, illustrates different situations of such reworks captured during field observation.

Fig. 4.5 (a) indicates the excavation or removal of locally failed surface course of asphalt roadway using excavator. Fig. 4.5 (b) shows the already cut surface in the same way to in (a) and events such as: stock pile of removed material in front the gate of AAUCNCS adjacent to the street, pedestrian crossing the disturbed zebra strip road signs and motorist using the same section of the road during the excavation or cutting of the roadway at middle distance from curb stone. Fig. 4.5 (c) indicates the excavated and/or cut asphalt surface nearest to curb stone around the manhole of sewerage line constructed, repaired and administered by AAWSA.

On the other hand, fig. 4.5 (d) illustrates the poor construction in which ‘circular sink’ of asphalt surface surrounding the manhole which detain water making temporarily ponded or standing there and gradually ingresses in to the interfaces of the courses and down to the base course of the road. Close observation of the street work and the explanation of the professional working at the site revealed that, the frequent failure of asphalt roads particularly, around manholes and the frequent excavations like in this case are due to poor construction of manhole which also due to incompetent workmanship and supervision. This means the situation in which the standing or ponded water at the sink ingresses horizontally through interfaces of base course and surface course separating them simply resulting in to the situation like in fig.4.5 (e) and down to the bottom layers loosening backfill materials below base course. Then, such events in both mechanisms result in frequent failure of the road and hence the need for maintenance and/or frequent repair.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Fig.4.6 as illustrated below is also one of the observed and captured events during the field observation of the researcher.



(a) Repeatedly repaired manhole & barriers to users



(b) Clogged/blocked manhole with removed cover



(c) Heavy vehicles over/mis using the road



(d) Damage and unsafe road to users

Fig. 4.6: Road damaged due to poorly constructed manhole (Captured by author on 2/11/2023)

The street work and road status illustrated in fig 4.6 is located at Akaki kaliti Sub-city, Woreda 05 to roadway of the asphalt road part between the areas locally called 'Berta Sefer' and 'Wuha

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

limat' near 'Mamme steel Factory'. Particularly, fig. 4.6 (a) illustrates the repairing or rework of manhole cover of sewer line. The researcher observed that this particular manhole and other nearest to it on the same road segment repaired at least more than twice in short period of time. Fig. 4.6 (b) shows the removed/displace metallic manhole cover, stones and rubber tyre placed around the uncovered manhole with the intention of safety or protection of life and properties from falling in to the manhole. Pond or standing water was seen near to the failed manhole. This and other neighboring manholes were aligned at center of the carriage way of the road. Such construction is not recommended unless there is no possibility of installing or constructing it along appropriate side(s) of the road. In addition to this, the level of manhole top and/or cover with respect to the level of road surface either may be lower, creating local circular sink where water detained and then ingress into sub-surfaces of the road or may be higher creating locally elevated hump like part. In such away, the manhole top or cover repeatedly hammered by all vehicles using the road which in turns damage the manhole and roadway in the vicinity.

Fig. 4.6 (c) and (d) indicated the standing water at damaged roadway section, heavy vehicles parking there and difficulty/inconveniency of road users. From close observation of the condition as illustrated in figure (d), one of the manholes was seen damaged and repaired repeatedly (gradually lowered like local ground subsidence) at the manhole and spreading out of the sides of the points by repeated traffic loading.

During the observation it could also be identified that the road segment was used by heavy vehicles such as dump trucks making repeated trips in both directions of the lanes to cart away materials from elsewhere and other heavy vehicles including high bed and low bed moving around the garages situated on both sides of this particular section of the road. On the other hand, water coming from the elevated side of the road through one of the garage also observed being flow and/or stand over the damage section of the road surface as indicated in figures (c) and (d).

From the above discussion, it seems that the frequent failure and hence frequent excavations or street works over the road segment and this particular location, were due to the combination effect of the listed and/or described causes. Except this damage several length of the road, the rest of most length with in the same segment of the street was seen being not damaged or not failed.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Arguably, this reveals that though the overloading and/or misusing of the roads beyond their capacity and/or functional categories (i.e. main/arterial road for heavy traffic volume & load versus local/access road) may contribute into the early damage and/or failure; the cause of damage or failure and hence frequent street works in this case, can be concluded as the poor construction or installation of the manholes and water flowing and/or standing over surface of the road at this particular location. These in turn were due to the poor technical and/engineering practices of human both professionals and non-professionals who were involved in the planning and designing, construction, maintenance and/or repairing of the road particularly, regarding manholes of the mentioned road segment.

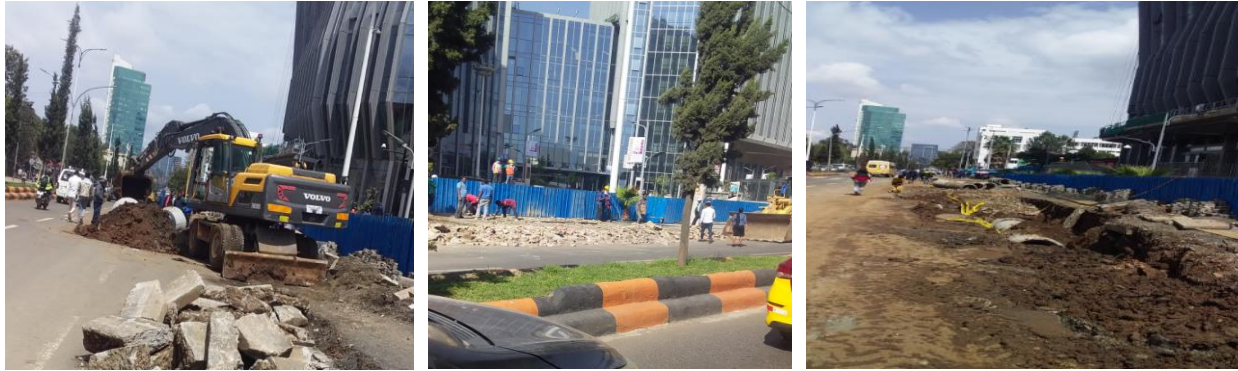
In general, the closer investigation of the researcher during the field observation of the situation and the above argument reveals that while the frequent failure and/or damage of the manholes and road around them were the intermediate causes, whereas the need for maintenance and/or repairing of them was the immediate cause of frequent excavations or rework, and human actions like in the other cases were concluded to be the root cause of this particular event and others similar to it with in Addis Ababa city.

4.4 Case studies of some observed frequent excavation events

The following excavation events (fig.4.7 up to fig.4.11) among the observed one were selected by the researcher, purposely because the excavations were undertaken more frequently than the other within short period of time after the former construction or installation takes place there. The events were analyzed by case studying as in the subsequent sub-sections.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Case 1: Trench & mass excavation to roadway & walkway of street near head quarter of CBE



(a) Excavation to roadway (b) Excavation & removal of sidewalk pavement (c) Installation of drainage pipeline



(d) Pedestrians & motorists sharing common roadway at excavated section (e) Google earth image location of the excavation site

Fig.4.7:Trench & mass excavation to street near head quarter of CBE (captured by author from 07/06/2022 onward)

The above pictures (fig.4.7) in general, shows that the excavation(street work) undertaken to walkway and roadway of the so-called ‘Ras Desta Damte street/Avenue’ on the lane just adjacent to the newly constructed head office building of Commercial Bank of Ethiopia (CBE). Fig. 4.7(a) and (c) illustrate that trench and/or mass excavation undertaken by excavator and the poorly reinstated surfaces after installation of concrete pipe of larger diameter than the formerly($\phi 60$ to $\phi 80$) had been using to discharge the storm water of the area respectively.

Fig. 4.7 (b) shows removed pavement of sidewalk and workers shoveling the removable material to loader for disposal and/or cart away. On the other hand, fig. 4.7(d) indicates the excavated roadway and walkway, excavator working there, as well as stacks pile of construction materials

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

on the walkway, all hindering the traffic along the lane. Fig. 4.7(e) is location of the excavation event marked by red colored line on Google earth.

Observation by the researcher and explanation of professional working at the site during the time (from 07/06/2022 up to completion of the work) revealed that, while the immediate cause of the excavation was upgrading capacity and function of storm water drainage pipe laid under the roadway closer to curb stone, the intermediate cause was seen to be failure of the pipe to properly discharge the drain.

Failure of the drainage system (unable to properly discharge), according to the professional, was due to the under capacity of the existing concrete pipe of diameter (600mm) and the additional inlet drain/storm water from the newly emerged CBE headquarter building. This argument can clearly indicate that in this case also there were technical problem particularly, design of the drainage line capacity of the particular area (i.e. forecasting capacity to match with future demand or requirement).

This indicates that root cause of the excavations was poor technical—planning and designing of the drainage system (i.e. there were no or merely consideration and/or forecasting future capacity of the pipe to discharge volume of storm water that could be collected from additional roof and surface in the vicinity) and poor communication between AACRA, AAWSA and stakeholders of CBE headquarter building what and how to do the accommodation work of the additional storm water to discharge via the existing line during the construction of the project rather than frequently excavating street components. The street was excavated at least three times within short period. Among these one of the excavations was due to elevation difference of drainage systems between CBE and ‘Gandhi Hospital’ locations which also again attributes to workmanship.

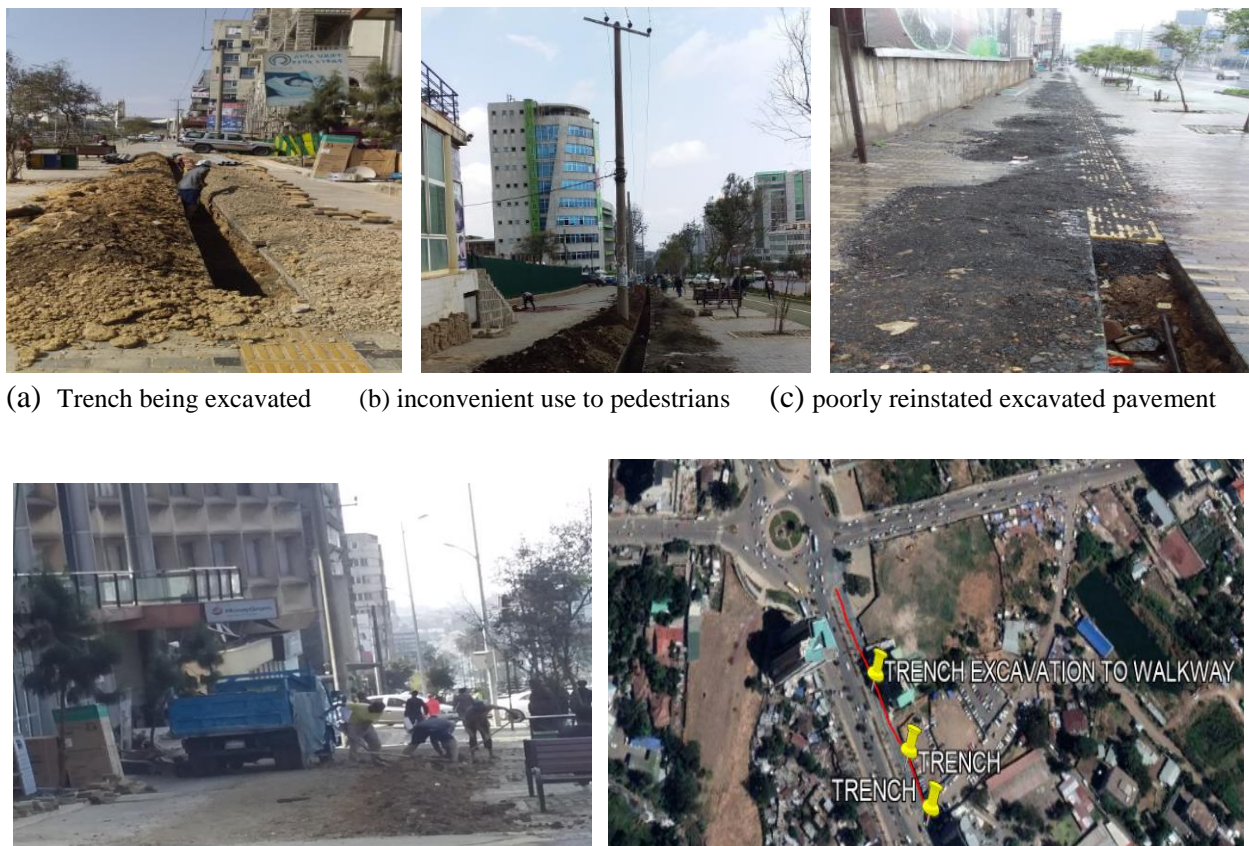
Case2: Trench Excavation to walkway of ‘Churchill Avenue’

The straight and sloppy street segment between the old rail station—“Legahar” at lower elevation and the public space in front of Addis Ababa city Mayor’s office located at higher elevation has been called “Churchill Avenue”. The street was recently widened being one of the contemporary initiations and/or implementation of the structure plan of Addis Ababa city (i.e.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

inner city and corridors redevelopment plan) particularly, to construct ‘boulevard’ for multifunction under the so-called Addis Ababa Mega projects construction office. Widening of the street components especially both side walkways was executed by relocating many private and public properties beyond the formerly existing setback or ROW of the street.

Trench excavations were repeatedly (on 9/6/2022, 12/01/2023, 31/01/2023 etc.) undertaken to the above mentioned newly expanded street or boulevard both in terms of time and location. Among these, the trench observed on 9/6/2022 being undertaken along the sloppy segment of the street at walkway near ‘Churchill Hotel’ was illustrated below in figure 4.8. The main focus of this case study was investigating the root cause(s) and impact(s) of the frequent excavations undertaken to the ‘boulevard’ after all most completion of the street work as illustrated in the following figure and analyzed below.



(a) Trench being excavated (b) inconvenient use to pedestrians (c) poorly reinstated excavated pavement

(d) Excavation & cart away activity in front of ‘Banko D’ Roma’ building (e) Google Earth map location of excavation sites

Fig.4.8: Trench Excavation to walkway of ‘Churchill Avenue’ (captured by author on 9/6/2022 & 21/9/2022)

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

As mentioned above, fig.4.8 indicates the trench excavated to the walkway and/or boulevard constructed widening the sides of “churchill street”. Fig.4.8 (a-c) indicate trench excavation to newly paved exactly along the guiding unique pavement for blind persons walkway of the street but at different chainages. Fig.4.8 (d) shows trench excavation and loading of cart away materials at one of the chainages particularly, in front of a business center near the building known as ‘Bancod Roma’ at which ‘Tewodros branch’ CBE exists, on opposite side to where ‘Eliana Hotel’ is located. Furthermore, fig.4.8 (e) revealed the general location of the excavation undertaken to sidewalk of this avenue marking the line of trench excavation by red colored line and yellow colored point locators/place mark on Google Earth. The figure, interview data (both that were made with a person working on the site and the one made with ETC interviewee at branch office fortunately situated on building near this mentioned excavation site) and the researchers’ inference of the occasions during field observation indicate that, there were frequent excavation to the existing street and/or newly constructed ‘boulevard’.

That means, during execution of civil works particularly, widening of the street, it is obvious that there would be a paramount earth work activities; Again the one illustrated in the figure—trench excavation were undertaken after the mentioned activities were completed including tiles/pavement of walkway which on the other hand, could be done formerly simultaneously had there been integration between the stakeholders. The figure further indicates that the trench excavations were undertaken exactly along the pavement with tiles of unique color and pattern guiding people with visual disability and the piled and spreaded excavated material all together blocking the walkway (making the travel inconvenient and unsafe for pedestrians especially, those who visually disabled) in addition to other imposed impacts such as rework or repairing costs.

According to the responses of both interviewee at work place during field observation and ETC professional interviewee at the branch office of Etio-telecom located at this excavation site, near “Churchill hotel”, the immediate cause of excavations were the need for repairing ETC’s pipes of utility lines damaged during the construction work by AACRA and installation of new fiber optic line for additional function particularly, CCTV camera.

Although the intention of the overall works were for improvement and/or to enjoy additional service of street amenities along the existing street like: walking, biking and public spaces

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

furnished with seats, the implementation/construction was suddenly emerged from higher officials of the government (not inclusive) according to the interviewee from ETC. The interviewee further argued that the construction of the boulevard was mainly intended politically for the then national election without integrated planning of the works with all necessary stakeholders. The interviewee also further disclosed that there were conflicts (blaming each other for the reworks and subsequent costs) among management team of the project and ETC regarding this particular case which was finally settled after discussion with higher officials from Mayor's office. This indicates that, human action through political practice or decision in addition to other problems (technical and integration), was the root cause of the frequent excavations and consequent impacts in this particular case.

Case 3: Trench excavation to right lane roadway of "Serra Leon Street"



(a) Accidentally shared roadway by pedestrians due to dumped material (b) Poorly reinstated trenched roadway



(c) Construction of missed drainage line

(d) Google Earth location of excavation sites

Fig. 4.9: Trench excavation to right lane roadway of "Serra Leon Street" (captured by author)

The so-called "Serra Leon Street" is a segment of the main road running from Addis Ababa Stadium to Kaliti, having two opposite lanes both on the right and left sides of the light rail along the

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

same corridor. Fig. 4.9 in general, indicates trench excavation or cut to asphalt surface of the right lane (when travelling to Quality by the light rail) of the street. Fig 4.9 (a) indicates the poorly reinstated trench after cutting the roadway, the stacked excavated material and hence roadway accidentally used by pedestrian and motorists commonly. Fig 4.9 (b) shows that the excavation was very closer to the curb stone and surface drainage inlet and the inconveniently reinstated roadway. Fig 4.9 (c) evidently indicates that the immediate cause of the excavation; that is the installation of drainage line, as the top of constructed manhole and/or its cover is seen at midpoint of the excavated trench to the roadway. In this case the observation revealed that the pipe or utility line was missed either during designing or during construction and/or failed properly discharging of the gray water because of lower capacity of the pipe. In all conditions the root cause was inferred to be human action related to technical or engineering practice particularly, poor planning, designing or construction of the road and/or drainage system at the segment.

Case 4: Manhole repairing & excavation to roadway of “Serra Leon Street” left lane



(a)Excavation & removal of solid waste from drainage line (b) Repairing drainage line (c) About overtuning traction trapped loaded vehicle



(d) Traffic congestion due to narrowed roadway segment under repair work (e) Google Earth location of excavation sites

Fig. 4.10: Manhole repairing & excavation to “Serra Leon Street” left lane (captured by author)

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

As discussed in case 3, the other lane of “Serra Leon Street” is the left lane along which traffic flows from Kality to Addis Ababa stadium. Figure 4.10 at all, illustrate the excavation and/or rework undertaken at the left lane of “Serra Leon Street”. In the figure, three specific conditions were indicated. Figure 4.10 (a) shows the workers removing different solid wastes that community carelessly disposed (which is ‘bad culture’) from manhole. The solid wastes include tyre, plastic sheets, plastic bottles etc. Figure 4.10 (b) reveals how the solid wastes clogs the sewer line and the exposure of worker to the toxic and/or gray water during such rework.

On the other hand, figure 4.10 (c) and (d) illustrate the excavated roadway and one of the subsequent impacts (traffic congestion) due to the excavation and/or street work. In figure 4.10 (e) line marked by red following the road indicates the location of the excavation event on the left side of this street on Google Earth. As it can also be seen from the figure, one of the medium but loaded vehicles was caught by the traction due to excavated material and moisten roadway and the heavy truck was pulling the trapped vehicle which altogether caused traffic congestion over the segment of the lane. Moreover, the picture indicates that the trapped vehicle was saved from nearly being overturned and propagation of further accidents.

In general, the need to remove solid wastes that blocked the sewer lines and the need to repair failed infrastructure (sewer line itself and the road surface due to washing away of the road surface by the upflowing gray water). Failure of the infrastructure due to the clogged sewerlines and hence up flowing and washing away of roadway surfaces were seen to be intermediate cause of the excavation.

Moreover, the field observation and response of road maintenance general foreman working at the site to the question of the researcher regarding the root causes revealed that human action particularly, the culture of misusing (in this case, illegal/inappropriate disposal of solid wastes-- in the drainage system) are the root causes of the excavation and/or the street work undertaken here.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Case 5: Excavation and reworks of damaged road elements at “Adey Ababa”



(a) Construction material and workers at repairing work (b) excavated pit and Vehicles versus pedestrian (c) repairing work



(d) Exposed and nearly missing utility strike

(e) Google Earth location of excavation site

Fig 4.11: Excavation and reworks of damaged road elements at “Adey Ababa” (captured by author on 15/12/2022)

The case in fig 4.11 in general was also captured by the author during field observation: that was rework at ‘Adey Ababa’ T-section of road and nearest asset, including utility damage. Drainage system was clogged and hence storm and sewer water was forced to back flow to the road surface which can be said the intermediate cause of the street work. The street work undertaken there include: cutting and resurfacing of the damaged surface course of the asphalt road, figure 4.11(a) material and workers on the street. Vehicles versus pedestrian and pit excavation (fig 4.11 (b)) around the intersections of drainage and/or sewer pipes near walkway at the spandrel of the T-section of the road where the street light and post was damaged and buried utility line particularly, electric power cable was nearly missed like in fig 4.11 (d)). The other activity was construction of masonry work for headwall (fig 4.11 (c)) and repairing work of the concrete pipe. Fig 4.11 (e) indicates the location of the excavation event on Google Earth being marked by L-shaped loop of line marked by bright blue color and yellow point location indicators at T-

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

intersection of the main road formed with the access road on left side. The bright blue line marked on the right indicates the excavation and manhole repairing activity mentioned in figure 4.11.

Over flowing/up flowing water combines with the effect of repeated hammering of vehicular movement, which in turn gradually washes away the road surface damaging it that eventually need repairing. Data from close observation of the phenomena and responses of professional workers of AACRA worked there indicated that, the drainage system particularly, pipes were gradually clogged/ blocked by different types of solid wastes that were directly thrown in or scattered by individual and/ or community over the walkways and roadways then entered in to the drainage and /or sewer system .

Author of this research asked that what the professionals working at the site think regarding the root causes of the rework and one of them particularly, the one who introduced himself as ‘road structural and maintenance foreman’ replied the following:

“Culture or behavior of individuals or community of the city, Addis Ababa, on usage and handling of infrastructure is not good, however, fast to comment and blame companies for such repairing or repeated excavations saying ‘always excavation, excavation, excavation!’ ...but throw every solid wastes such as plastic bottle, chat residue or stick and other”.

Response of the professional reveals that culture or behavior of individual and community of Addis Ababa city regarding usage and handling of infrastructure particularly, actions such as carelessly and illegally disposing every solid wastes in drainage system, resulted in to failure of the drainage system—intermediate cause of the infrastructure which in turns lead to the need for repairing—immediate cause, of the damaged part and hence excavations or rework. Moreover, the analysis indicates that human actions in terms of poor culture or behavior of using and handling public assets is the root cause of the failure and/or rework of this particular case.

❖ Impacts of the excavations/street works :

- **Rework/repairing cost of failed infrastructure:** this is the direct repairing cost (materials, labor, tools and equipment). Different activities were undertaken before and after in addition to the earth work. For instance, repairing cost of failed (damaged) infrastructures described in the above cases (excavation to ‘Saris Adey Ababa’ intersection road, the road near new

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

building of CBE head office and to the road around ‘Global Hotel’ or “Serra Leon street”) were observed in case study. These costs were quantified to be **10,223,796.48 Birr** as can be seen from the following table 4.3 which was obtained from AACRA Road Maintenance Project Management Team but processed a little bit by the author of this research.

Table 4. 3: Construction /repairing costs of frequently failed and/or excavated street elements

No.	Location	Unit	Work Activity				Remark
1	Saris Adey Ababa intersection	ml	Asphalt Base Patching	Asphalt Overlay	Curb Stone	Tiles	
			205.71	141.43	100	50.00	
Total Cost		Birr	5,808,727.01				
2	"Ras Desta Dmte Street" (near CBE headquarter at the new skyscraper Building)	ml	Curb Stone	Tiles		-	
			160	105.35		-	
Total Cost		Birr	555,567.39				
3	"Serra Leon Street" (around Global Hotel)	ml	Asphalt Base Patching	Asphalt Overlay		-	only one side
			172	90.00		-	
Total Cost		Birr	3,859,502.08				
Grand Total Cost		Birr	10,223,796.48				

Source: (Road Maintenance Project Management Team of AACRA, processed by author)

The table indicates that how much the reworks or repeated excavations cost than the inevitable maintenance costs of infrastructure. Although the repairing costs of each activity and each site lacks detail quantification due to shortage of data from respondent, this rough quantification by itself clearly indicated that how much larger the repeated repairing work or excavations to existing infrastructure will be and negatively affecting economy.

- **Operational costs:** include but not limited to indirect costs such as traffic congestion related costs, costs related to strike damage utilities hence service interruption and loss of customers hence income due to difficulties of access to businesses and service centers where trenches and piled earth materials around the excavated street are seen. There was traffic congestion over a long segment of the road because the loaded vehicle trapped by the semi-muddy and loosely filled trench at the rework site that was also nearly being overturned but was saved being pulled by other heavy vehicle. Though it could not simply be expressed in terms of

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

money, there were also many loss of resources and income in terms of time, fuel etc. which in general, affect economy of individual, business firms and city as well as the country at all.

- **Societal (Health & Safety/convenience) impacts:** in addition to the pollution of air by vehicles within the queue and contaminated slurry from clogged drainage and/or sewers system that can affect health of individuals, there was inconvenient traveling of pedestrian as well as high probability of vehicular accident to road users and mainly to workers working there. As also mentioned earlier, fig.4.10 (c) in case 4 above for instance, indicates that the loaded medium vehicle was seen about to be overturned due to the earth work being undertaken repeatedly there. It was inconvenient for all users (both for motorists and pedestrians) moving around the vicinity.
- **Environmental and Aesthetic impacts:** cut and patched area of the road do not looks good because its appearance is not similar with the original surface either creating roughness and/or uneven surface or in color. There were also spread and stocked piles of earthy and waste materials removed from drainage system, excavated streets and dumped construction materials all resulting in to muddy, dusty and dirty environment in addition to health impact which also affect the looks or the overall beauty of the roads and/or streets and hence that of the city at all.

Except the rough estimation of repairing costs (table 4.3), the other costs or impacts due to the reworks were not quantified in terms of money as it was not possible to do so because it was not in the scope of the study but identified and described qualitatively above. In general, the impacts were obviously identified from the cases to be aesthetically poor/non-attractive appearance, dusty and muddy area of the city, exposure of stakeholders to accident and inconvenient travel to the pedestrian, traffic congestion, services interruption for instance Transportation(due to the excavated and/or damaged road segment) and direct cost of repairing the failed infrastructure.

- **Result from analysis of secondary data --** video of ‘National Integrated Infrastructure Development’ panel discussion: (<https://youtu.be/LhwtykfQjVA?si=LJMIX-GDdfCz-SHv>) titled ‘Cities and infrastructure day’:

In addition to the above secondary data(repair costs of frequently excavated street elements of Addis Ababa--see table 4.3), video of panel discussion by member committee of ‘National Integrated Infrastructure Development’ was analyzed as also mentioned earlier in section 4.2.5.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Five representatives of different organizations including the journalist who led the discussion were involved in the discussion which mainly focused on the integration status of infrastructural stakeholders and consequences or impacts due to lack or absence of information and integration.

During the conversation, the journalist asked the first question that invites one of the members as follows:

“Let me go back, indeed in the previous years was there implementation of ‘integrated infrastructure construction’ in our cities and/or country? “

The interviewee came from MUI with position ‘Executive leader of National Integrated Infrastructure ’ answered that there was effort of establishing and implementing of such integration since 2006 E.C. in which for example from ad - hoc committee to today’s stage BY proclamation but there was no robust integration. The journalist forwarded the second question as follows inviting all of the members to react on it:

“If there was no integration of stakeholders in infrastructure works before 2006 E.C, what and how much were the consequences or impacts (paid value)?”

The interviewees replied that there were too much damages of earlier constructed/installed utility lines and roads by one or more of the late coming companies which in turn results in huge economic impact due to services interruption ,loss of revenues and repairing costs. Although the discussion was longer, the main idea was revolved around the aforementioned one—absence and/or lack of integration among infrastructural stakeholders.

4.5 Quantitative Analysis: Analysis of questionnaire survey data

4.5.1 Rate of Response

Questionnaire survey data collection method was used to supplement the other two mainly employed methods (Field observation and face-to-face interview). A total of 24 questionnaires from which 12 of them distributed to Ministry of Urban and Infrastructure (MUI) professionals and the other 12 to Addis Ababa Construction Permit & Control Authority(AACPCA) professionals working at the infrastructural sectors, to collect data for measurement of the perception of respondents of the two groups .

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Although 20 (83.33%) of the questionnaire were returned or collected back, only 11(45.83%) of the questionnaire, those fully completed were analyzed after excluding the rest portion that were incomplete to increase the clarity and reliability of the data and/or result. Thus, data analysis and interpretation were based only on the number of complete questionnaire (11) though the total number of distributed & sample was 24.

4.5.2 Descriptive Analysis

Data that analyzed here under (descriptive analysis section) were collected by larger portion of the questionnaire which include questions 1 up to 7 and partly question 8 on the ‘Agree’ or Dis agree’ contents of the questionnaire. These include the data collected via questions situated under three sections of the questionnaire: General information of respondents, Impacts identification and related data and the section under which data for root causes investigation were collected. As mentioned in methodology this portion of the data were analyzed using mean score or average score in which frequency distribution method was dominantly employed.

a. General information of respondents:

Table 4.4: General information of respondents of questionnaire survey

Description	Number of respondents/Frequency		
	MUI	AACPCA	Total
1. Education Status			
BSc	1	4	5
MSc	3	2	5
PhD	0	0	0
Other	1	0	1
2. Level at job position			
General/deputy Manager	1	0	1
Director	0	0	0
Team Leader	1	1	2
Senior	3	5	8
Junior	0	0	0
3. Experience in Year			
< 5	0	0	0
5-10	2	3	5
10-15	0	2	2
>15	3	1	4

Source: Author’s analysis summary of questionnaire survey

Table 4.4 and graphs and/or fig.4.12 reveal backgrounds of respondents to questionnaire survey regarding education status, level at job position and experience. Number of BSc. and MSc.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

degree holders are equal 5(45.45%) together equals 10 (90.9%) among the whole respondents whereas, 1(9.1%) was MA degree holder which was categorized as ‘other’ and no one of the respondent was at PhD level.

The table and the figure also show that, one of the respondents, particularly, that working at MUI in infrastructure sector was a general manager and 8 were at senior and 2 were at team leader level. Regarding experience of the respondents, the table further indicated that 5(45.45%) of the respondents have experience ranging from 5 to 10 years and 4(36.36%) of the respondents had worked for more than fifteen years, whereas only 2(18.18%) of them have an experience of 10 to 15 years.

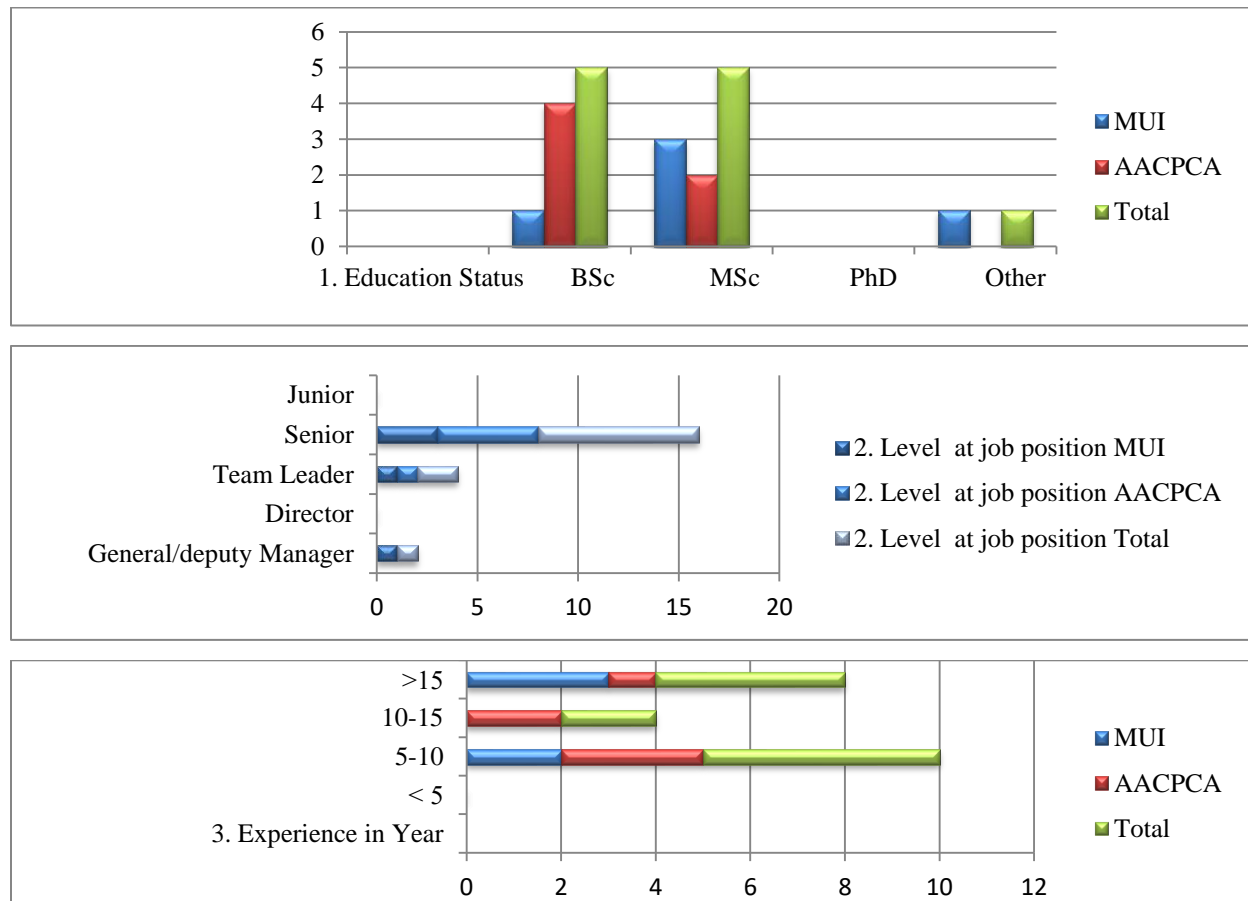


Fig .4.12 Education Status, Level at job position and Experience in Year of respondents

In general, the data indicates that the respondents are relatively highly educated, experienced and are working at higher positions in the infrastructural sectors of the two companies.

b. Data on frequent excavation impacts investigation and related issues

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Table 4.5: Responses and corresponding number of respondents to impacts investigation questions

No.	Question	Provided options and/or responded answers	Number of respondents to each option		
			MUI	AACPCA	Total
1	Frequent excavations are common practice in Addis Ababa	Strongly Agree	2	5	7
		Agree	3	1	4
		Neutral	0	0	0
		Disagree	0	0	0
		Strongly Disagree	0	0	0
2	Frequent excavations and /or street infrastructural works have impacts on:	Health and Safety aspects of users	0	1	1
		Aesthetics and/or beauty of the city	0	0	0
		Economic and/or sustainable development aspects of individual, community etc.	0	0	0
		All of the above	5	5	10
		Others in addition to these (list them if any)	0	0	0

Source: Author's summary of questionnaire survey

Table 4.5 and figure 4.13 show that 7(64%) of the respondent *Strongly Agree* and 4(36%) of them *Agree* that frequent excavations are common in Addis Ababa City.

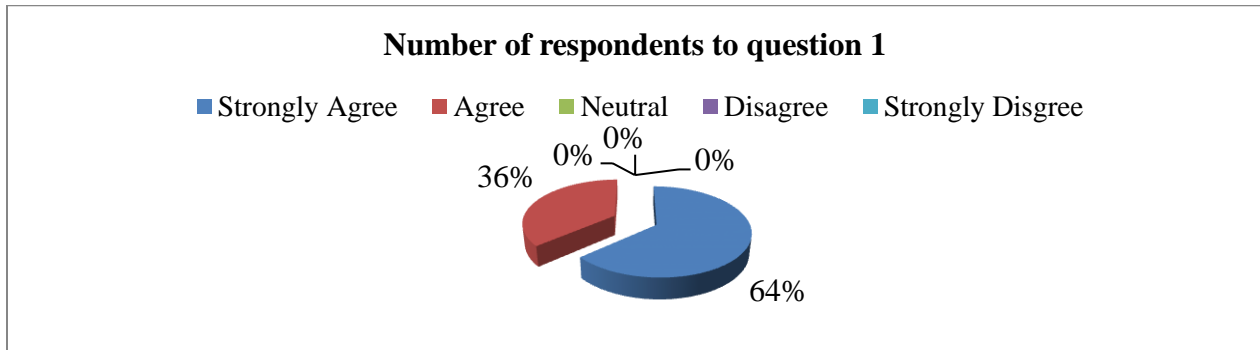


Fig. 4.13: Number of respondents to each options of impact investigation question 1

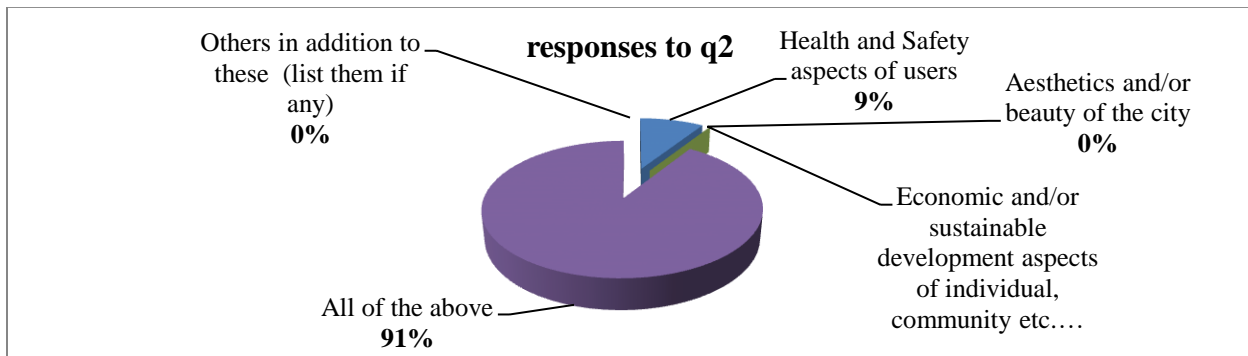


Fig. 4.14: Number of respondents to each options of impact investigation question 2

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Regarding impacts of frequent excavations within in the city, all most all of the respondents, 10 of them as can be seen from table 4.5 which is 91% from figure 4.14, confirmed that all of the proposed and/ or those listed as optional answer to question 2 of the survey are impacts imposed due to frequent excavations of existing city infrastructure. Only 1(9%) of the respondents identify ‘Health and Safety aspects of users’ as the exceptional impacts of FECCI in Addis Ababa.

C. Data on frequent excavation causes investigation and related issues

Table 4.6: Analysis summary of responses to questions 3, 4, 5, 6 and 7 of questionnaire

No.	Question	Provided options and/or responded answers	Number of respondents/frequency of response/average score and rank to each option			Techniques	Result	Rank of importance
			MUI	AACPCA	Total			
3	Which of the following <i>intentional and/or unintentional human actions</i> do you think is/are the root cause(s) for poorly constructed/ installed, managed hence early and frequent failure of existing infrastructure in the case of Addis Ababa city?	Corruption acts of technical and political stake holders	1	2	3	Ratio or proportion	3(27.27 %)	3
		Bad culture or behavior of community in infrastructure handling/usage	1	4	5		5(45.45 %)	1
		Terrorism, conflict/war due to instable political situations	0	2	2		2(18.18 %)	4
		Errors of engineering computations and estimations during designing	1	3	4		4(36.36 %)	2
		Negligence and adherence to traditional					4(36.36 %)	

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

		infrastructure working/installation methods	1	3	4			2
		All of them are root causes	3	1	4		4(36.36 %)	2
4	Please <i>rank</i> in the order of their occurrence frequency if your response for the above question is “All or some” of them and list other root causes you think	1 st	5,1,2,1,5	5,1,4,2,2,1	5,1,2,1,5,5,1,4,2,2,1	Mode	1	1
		2 nd	5,4,5,2,4,4	2,4,4,5,2	5,4,5,2,4,4,2,4,4,5,2		4	4
		3 rd	4,5,4,5,2,2	4,5,1,4,1	4,5,4,5,2,2,4,5,1,4,1		4 & 5	5*
		4 th	2,1,1,5	3,3,2,4	2,1,1,5,3,3,2,4		1,2&3	2*
		5 th	3,3,3,3	2,5,3,3	3,3,3,3,2,5,3,3		3	3
5	Which of the following do you think is/are the probable root causes of frequent failure and/or excavations of existing infrastructure occur(s) during <i>planning</i> and <i>design stage</i> ?	Absence or unreliable feasibility study for infrastructural works	1	0	1	Ratio/ propo	1(9.1 %)	3
		Lack of transparency or participatory infrastructure planning & decision making	1	2	3		3(27.27 %)	1
		Mismatched capacity/standard of existing infrastructure with demand/requirement due to poor forecasting/pr	0	2	2		2(18.18 %)	2

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

		ediction				rtion		
		Erroneous/incorrect engineering calculations during design	1	0	1		1(9.1 %)	3
		Lack of design review & checking before starting any infrastructural works	0	0	0		0(0.0 %)	4
		Lack of communication and coordination of infrastructural companies	1	2	3		3(27.27 %)	1
		All of the above	4	4	8		8(72.73 %)	
	Write “1” or “2” in the space provided to indicate that you “Agree” or “Disagree” respectively that the following is/are root cause of frequent failure and/or excavations to existing	Using inappropriate/lower quality and quantity material than the specified : 1/2	3	4	7		7(63.73 %)	Agreed
			2	2	4		4(36.64 %)	Disagreed
		Using unqualified and/or uncertified workmanship : 1/2	2	5	7		7(63.73 %)	Agreed
			3	1	4		4(36.64 %)	Disagreed
		Lack or absence of strict inspection/supervision during construction/installation :	4	5	9		9(81.82 %)	Agreed
			1	1	2		2(18.18 %)	Disagreed

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

6	infrastructure of Addis Ababa that may happen during construction /installation of new infrastructure or maintenance or repairing of the existing	1/2				Ratio (proportion)			
		Trial excavations due to absence of information & documents on exact location of buried utilities : 1/2	3	4	7		7(63.73 %)	Agreed	
		Absence of using technologies and/or alternative utility installation techniques: 1/2	2	2	4		4(36.64 %)	Disagreed	
		Absence/inapplicability of guidelines, standards and specifications for infrastructural works: 1/2	5	5	10		10(90.90 %)	Agreed	
		Poor infrastructural construction/ installation and maintenance techniques :1/2	0	0	0		0(0.0 %)	*	
			4	4	8		8(72.73 %)	Agreed	
			1	2	3		3(27.27 %)	Disagreed	
			4	6	10		10(90.90 %)	Agreed	
			1	0	1		1(9.1 %)	Disagreed	
		Rate out of 10 marks (writing 10, 9, 8...1 as per your experience based judgment on the provided	Lack of regular maintenance or pending of it	7.4	8.3		7.9	2	2
			Culture of misusing and/or inappropriatel	9.00	6.8		7.92	1	1

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

7	space) the following root causes of frequent failure and/or excavations assumed to be happen <i>during operation</i> and maintenance of the existing infrastructure of Addis Ababa.	y handling infrastructure				Average /mean score		
		Terrorism, war/conflict vandalism and theft actions of people to infrastructural asset	5.2	4.3	4.8		4	4
		Accidental events(strike/collision & explosion) due to carelessness or unconsciousness	5.2	5.3	5.3		3	3

Source: Author’s summary of questionnaire survey

The above table, (table 4.6) shows the result of participants’ responses to the five: 3rd, 4th, 5th, 6th and 7th questions of the questionnaire survey. These questions in general were designed to investigate the root causes of early and frequent failure of the existing city infrastructure, hence root causes of frequent excavations to those infrastructure or vice versa. Specific features of each question are the way the question asked, the way optional responses were provided and the way the participants responded all of which illustrated in this table.

4.5.2 .1 Indicators of human actions as root cause(s) of FEECI and their importance

In response to question 3 of this portion, six response options that were collected from previous literatures and observation of the author were proposed as manifestations of intentional and unintentional human actions as root causes of early and frequent failure of existing city infrastructure and hence frequent excavations or vice versa. Among the options, the first five were proposed to be independent indicators of the problem under study and the sixth option was provided with the respondents to choose and/or if they choose all as indicators. Accordingly, the respondents were asked to choose one or all of the provided indicators of human intentional—

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

corrupted and unintentional—erroneous actions as root causes of the problem occurring during the engineering practices.

While ratio and/or portion were used as analysis technique for this particular question, the table indicates that the result was seen to be as follows:

Among all, 5(45.45 %) of respondents indicated that *'Bad culture or behavior of community in infrastructure handling/usage'* is the most important indicator of intended and unintended human actions against city infrastructure. *'Errors in engineering computations and estimations during designing'* and *'Negligence and adherence to traditional infrastructure working/installation methods'* were equally perceived by 4(36.36 %) of the respondents being the second most important indicator of intended and unintended human actions as root causes of the problem. On the other hand, the same number, 4(36.36 %) of respondents thought that all of the options provided are the indicator of intended and unintended human actions as root causes of frequent failures, hence frequent excavations or vice versa of existing infrastructure of Addis Ababa city.

The result of analysis to this question 3 further indicates that *'Corruption acts of technical and political stakeholders'* and *'Terrorism, conflict/war due to instable political situations'* were believed by 3(27.27 %) and 2(18.18 %) of respondents respectively. Accordingly they were seen to be the third and fourth important indicators of the intentional and unintentional human actions as root causes of frequent infrastructure failures, hence frequent excavations or vice versa of existing infrastructure of Addis Ababa city respectively. On the other hand, 2(18.18 %) of respondents perceived and/or considered *all* of the options as indicators of intended and unintended human actions to be root causes of the problem under scrutiny. To further visualize, the results also illustrated by graph, below as in fig. 4.15.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

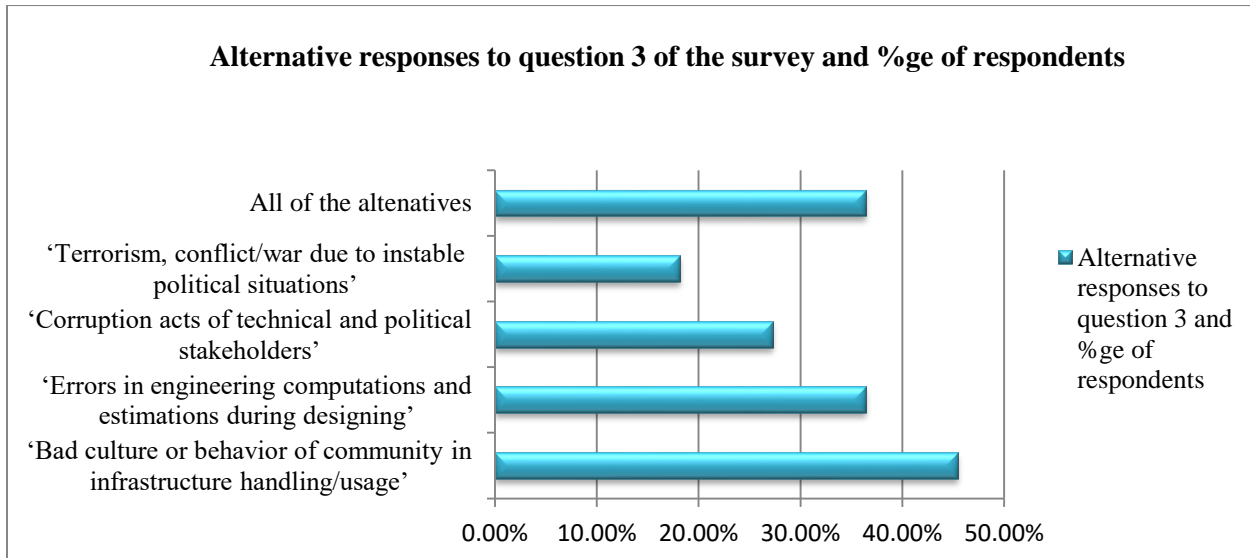


Fig.4.15: Alternative responses to question 3 and % ge of respondents

As elaborated above the graph shows percentage of respondents that perceived the corresponding alternative response are indicators of human intentional and unintentional action as root causes of frequent failure of infrastructures and hence that of frequent excavation in Addis Ababa city.

Question 4 is dependent on question 3. That means; the items listed in question 3 themselves were going to be ranked here in their occurrence frequency order. This question thus requests that let the respondents rank the items in their frequency order as first, second, third, fourth, fifth if they choose all or some of the indicators as root causes of early and frequent failure of existing city infrastructure hence frequent excavation within Addis Ababa.

As such, measurement of central tendency particularly; mode was utilized to rank the factors that in this case were the most frequent response(s). Accordingly, the following were obtained from analysis of the responses:

1. For the data set or responses data (5,1,2,1,5,5,1,4,2,2,1) obtained as a result of ranking the listed factors as first or as the most frequently occurring, '1' is the most frequent, that means it is mode of the above data set. This means, most of the respondents ranked the indicator listed on number '1' particularly, '*Corruption acts of technical and political stake holders*' as the most frequently occurring indicator.
2. Mode of the data set (5,4,5,2,4,4,2,4,4,5,2) was seen to be '4' indicating that the factor listed on the fourth serial number specifically, '*Errors in engineering calculations and estimations*

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

during design' was ranked as the second most frequently occurring indicator of intentional and unintentional human actions in the course of infrastructural works.

3. Modes of the rest were identified from their respective response data sets in the same fashion to the above. Accordingly, two modes of the data set (4,5,4,5,2,2,4,5,1,4,1) were seen to be '4' and '5'. Since the indicator listed on the fourth order was ranked to be the second most frequently occurring, obviously '5' have to be selected in this case to be mode of this data set there bay indicating that the factor listed in fifth order '*Negligence and adherence to traditional infrastructure working/installation methods*' was ranked as the third most frequently occurring and '5*' was illustrated in the table to show that '5' was selected from the two modes.
4. Again in the same fashion, for data set (2,1,1,5,3,3,2,4) three modes were seen to be '1,2 & 3' and with the same reasoning to the above, '2*' in last column of table 4.6 indicates that '2' have to be selected as mode of the data set because among the possible modes '1' and hence corresponding indicator was already selected and/or ranked as the first most repeatedly seen indicator of human actions as root cause of frequent failure and frequent excavation to existing city infrastructure or vice versa .

On the other hand, '3' was not considered as mode in this particular dataset as it is going to be mode of the next and last data set of this question. Therefore, the analysis shows that the item listed on the second order in question 3 particularly '*Bad culture or behavior of community in handling/usage of infrastructure*' was ranked by respondents as the fourth most frequently occurring indicator of human actions as root causes of infrastructural rework in Addis Ababa city.

5. As mentioned above, '3' was identified to be mode of data set (3,3,3,3,2,5,3,3) which revealed that according to the perception of the respondents the response option listed on the third order particularly, '*Terrorism, conflict/war due to instable political situations*' is the least(fifth) indicator of human actions as root causes of frequent failure and hence frequent excavation or vice versa to the existing city infrastructure.

Possible root causes of FEECI in Addis Ababa: At infrastructure planning and design stage:

In question 5 of the questionnaire respondents were asked to select or indicate the possible root cause(s) of frequent failure and/or excavations to the existing city infrastructure they think

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

occur(s) during planning and design stage of infrastructure, among the seven provided alternative indicators from which the last alternative is the possibility of selecting all of the five alternatives if so and the participant believe as such. Possible or proposed root causes of the problem under study were listed vertically in the third column of table 4.6 and horizontally within the rows correspondent with question 5.

Like in question 4 of the questionnaire, frequency distribution particularly, ratio was used to analyze and interpret the responses of subjects to this particular question 5 of the survey. Accordingly, 8(72.73 %) of the respondent selected the sixth option, which says '*All of the above*' that means all of the six proposed alternatives to be possible root causes of the frequent failure and hence excavations or vice versa to the existing infrastructure of Addis Ababa occurring during planning and design stage were also perceived by most of the respondents. On the other hand, no one of the respondents (0.00%) selected one of the alternatives particularly, '*Lack of design review and checking before starting any infrastructural works*'. This may seem a paradox with respect to the above response that revealed most (72.73 %) of the respondents select all of the alternatives as possible root causes. Rather, this is due to the fact that there are two ways of selecting the provided alternative responses either selecting one, some or all of them.

Therefore in this case, it can be argued that no one of the respondents (0.00%) considered it as possible root cause of the problem under study. But, this does not mean it is not the root cause rather, it indicates that no one of the respondents separately selected it as one of or some of the item but those who selected '*all*' perceived that '*Lack of design review and checking before starting any infrastructural works*' is among the possible root causes of the problem. However, when considered in the relative importance point of view, the result indicated that, it is the *fourth /least important* among the possible root causes occurring during planning and design stages of infrastructure.

Similarly, some of the respondents selected only several items or alternatives among the proposed possible root causes. For instance, both '*Lack of transparency and participatory infrastructure planning and decision making*' and '*Lack of communication and coordination of infrastructural companies*' were equally selected by 3(27.27 %) of the respondents which

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

indicates both are equally most important than the rest as indicated in the last column of the table ranked by '1'.

In the same manner, '*Absence or unreliable feasibility study for infrastructural works*' and '*Erroneous/incorrect engineering calculations during design*' were equally perceived both by 1(9.1 %) of the respondents. These items were seen from the analysis being equal and the third most important with respect to the entire root causes listed in this particular question or category as they were labeled by '3' in the last column of the table corresponding to the rows of the items. Furthermore, the *second most important* possible root cause of FEECI due to poor planning and design of infrastructure. In the case of Addis Ababa, it was identified by the analysis to be '*Mismatched capacity/standard of existing infrastructure with demand/requirement due to poor forecasting/prediction*' evidently being selected by 2(18.18 %) of the respondents and ranked as second as labeled by '2' in the ranking column of the table above.

In general, analysis of the data revealed that all of the proposed items are the probable root causes of FEECI of Addis Ababa that occur in relation to planning and design stages of infrastructures.

Root causes of FEECI: Construction of new, maintenance/repairing of existing infrastructure:

The responses data to question 6 of the survey were analyzed in relation to this category (construction/installation of new, maintenance or repairing of the existing infrastructure). The analysis technique of this question was similar to that of question 5. That means, frequency distribution particularly, ratio was used here also. The only difference is, that in this present question, respondents were restricted to respond to each of the listed probable root causes either by writing '1' indicating that he/she 'Agree' that a particular item among the options is a probable root cause of FEECI in Addis Ababa for construction/installation of new, maintenance or repairing of the existing infrastructure, or by writing '2' to indicate that they '*Dis agree*' with the premise.

As such, the analysis indicated that, 7(63.73 %) and 4(36.64%) of the respondents 'Agreed' and 'Disagreed' respectively that '*Using inappropriate/lower quality and quantity material than the specified*', '*Using unqualified and/or uncertified workmanship*' and '*Trial excavations due to absence of information & documents on exact location of buried utilities*' are the root causes of FEECI in Addis Ababa during construction/installation of new, maintenance or repairing of the existing infrastructure.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

'Lack or absence of strict inspection/supervision during construction/installation' was 'Agreed' by 9(81.82 %) and 'Disagreed' by 2(18.18 %) of the respondent in considering it as one of the root causes of FEECI in Addis Ababa especially, during construction/installation of new, maintenance or repairing of the existing infrastructure listed in this category.

Among the subjects, 10(90.90 %) of the respondents 'Agreed' that *'Absence of using technologies and/or alternative utility installation techniques'* and *'Poor infrastructural construction/installation and maintenance techniques'* are root causes and 0(0.0 %) and 1(9.1 %) of the respondents 'Disagreed' to the first and second premises respectively. On the other hand, 0(0.0 %) indicated that one respondent did not respond either by 'Agreeing' or by 'Disagreeing' to the first premises as the root cause of the problem for which * was indicated in the last column of the table corresponding to the response to remind this implication.

The analysis further revealed that 8(72.73 %) and 3(27.27%) of the respondents 'Agreed' and 'Disagreed' respectively that *'Absence/inapplicability of guidelines, standards and specifications for infrastructural works'* is another root cause of the problem among this category.

Arguably, all of the items proposed and identified in this category as root causes of FEECI in Addis Ababa during construction/installation of new, maintenance or repairing of the existing infrastructure can be ranked from the most to least important root cause based up on the corresponding ratio of agreed respondents. Accordingly, the root causes that corresponds to 10(90.90 %), 9(81.82 %), 8(72.73 %) and 7(63.73 %) ratio of agreed respondents were ranked as the most, second most, third most and least most important respectively requiring more attention to construction/installation of new, maintenance or repairing of the existing infrastructure to avoid and/or minimize FEECI of Addis Ababa and even of other cities.

Root causes of failure & FEECI related to operation, maintenance and their relative importance:

To investigate and/or identify the root causes of failure & FEECI to existing infrastructure of Addis Ababa that may happen during operation and maintenance and their relative importance, the researcher requested the respondents that, let they rate the assumed alternative as root causes from 10 to 1 value in question 7 of the survey. Then mean/average score was used to analyze the responses data in which highest rating value 10 to lowest rating value given by all respondents were averaged for each of the assumed root causes. Accordingly, the analysis of the data in table

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

4.6 shows that the average or mean rating of 7.92, 7.9, 5.3 and 4.8 were obtained being ranked as first, second, third and fourth respectively.

Moreover, the result indicated that ‘*Culture of misusing and inappropriately handling of infrastructural assets*’, ‘*Lack of regular maintenance/pending of regular maintenance*’, ‘*Accidental events(strike/collusion & explosion) due to carelessness or unconsciousness*’ and ‘*Terrorism, war/conflict vandalism and theft actions of people to infrastructural asset*’ with their corresponding average rating values and ranks were identified to be the most, second most, third most and fourth or least most important root causes of FEECI occurred during the operational/usage and /or maintenance stage of the existing infrastructure of Addis Ababa city.

As detailed earlier, the last but not least question the questionnaire survey of this research is question 8th. This question consists of twenty four (24) items and/or indicators of intended (corrupted) and unintended (due to error) human actions as root causes of early and frequent failure and hence FEECI in Addis Ababa. In this question, the two groups of respondents (professional personnel of MUI—Ministry of Urban and Infrastructure and —AACPCA Addis Ababa Construction Permission and Control Authority) all working at infrastructural issues and related positions were requested to respond in two ways.

First they were requested to put mark to correspondent response options to show either they ‘Agree’ or ‘Dis agree’ to each of the 24 indicators as mentioned above. Secondly they were requested to rank the indicators in the order from they think most important (indicated during response by 1 or 1st) to least important (indicated during response by 24 or 24th). Both types of the responses were separately analyzed in table 4.7 and table 4.10 respectively. The first part of the response (‘Agree’ or ‘Dis agree’) to the statements was intended by the researcher to supplement and summarize the descriptive part of the questionnaire discussed earlier and analyzed as in table 4.7 below.

Table 4.7: Analysis summary for response to question 8 of questionnaire for descriptive part

Indicators of human actions predicted as root causes of FEECI	Average/mean number of/ records from respondents of both companies to each factor		Total
	MUI	AACPCA	

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

	Agreed	Disagreed	Agreed	Disagreed	Agreed	Disagreed
I. Human actions during Technical (Engineering and Technological) practices						
1.Planning and Designing stage						
1. Spontaneous origination and sprawl development/ organically without master plan/ of Addis Ababa city	4	1	4	2	8	3
2. Lack/absence of feasibility study before starting any infrastructural work	4	1	4	2	8	3
3. Lack/absence of inclusion input data and/or comments of concerning stakeholders particularly, community	3	2	5	1	8	3
4. Incorrect/erroneous engineering computations and specifications during designing	2	3	3	3	5	6
5. Lack/absence of design review and checking before starting new construction and maintenance of infrastructure works	4	1	4	2	8	3
2.Construction/implementation stage						
6. Lack/absence of planning & scheduling for infrastructural works	4	1	3	3	7	4
7. Poor/inappropriate infrastructure construction/installation methods/techniques	5	0	6	0	11	0
8. Use of inferior resources(material, man power, machinery, tools and equipment) than specified and quantified	2	3	4	2	6	5

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

for particular infrastructural works (corruption practices)						
9. Lack/absence of alternative utility installation methods(MUT,TT) other than the traditional open cut	3	2	4	2	7	4
10. Lack/Poor marking, mapping and documentation of exact location of buried utility lines/assets hence try and error excavations to detect any buried utility	The values were removed only leaving the content of the item simply for the sake of recalling					
11. Absence/inapplicability of reliable specifications, standards, guidelines and legal frames for infrastructural and related works and Management	5	0	5	1	10	1
12. Lack or absence of strict supervision during construction/installation and maintenance	The values were removed only leaving the content of the item simply for the sake of recalling					
3. Operation, Maintenance Disposal stages						
13. Lack/absence of regular and/or proactive maintenance						
14. Overload/miss-utilization of infrastructures beyond their design capacity and/or their purpose	4	1	6	0	10	1
15. Absence/poor implementation of initiatives such as SUE, MTU/urban underground space utilization & advanced	The values were removed only leaving content of the item simply for the sake of recalling					

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

technologies such as GPR, etc.						
16. Damage due to Vehicular Strike and/or other explosive accidents	1	4	3	3	4	7
17. Lack of cooperation, coordination and communication between infrastructural companies during planning, scheduling and implementing infrastructural works & before starting any excavation works	3	2	5	1	8	3
II. Political actions/practices/leverages						
18. Lack/absence of transparent and inclusive decision making for infrastructural works	4	1	5	1	9	2
19. Politicians promising for provision of new infrastructure as reward of more support and future vote /election(‘pork barrel’) that will not be feasible and/or deliverable at good quality & reasonable time	2	3	4	2	6	5
20. Undertaking unnecessary new and reworks of infrastructures pretending it as ‘creating job opportunity’	2	3	4	2	6	5
21. Unnecessary interference and urgent decision and/or making alteration by higher officials/politicians against technical	2	3	6	0	8	3

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

requirements of infrastructure						
22. Diversion of resource allocated for public infrastructure to other private or group advantage	3	2	5	1	8	3
III. Cultural and/or Behavioral practices						
23. Misuse of existing public infrastructure (e.g. as storage of construction materials, solid waste disposal place) for other purpose than the intended ones and/or poor handling of public assets	4	1	4	2	8	3
24. Vandalism and/or theft acts to infrastructural assets	2	3	4	2	6	5

Source: Author’s summary of questionnaire survey

Table 4.7 consists of seven columns: the first indicates lists of the indicators under several categories, the second and fourth columns indicates number of respondents agreed to the idea of the indicators and third and fifth columns shows the number of respondents disagreed to the idea of listed items for MUI and AACPCA respectively. The sixth column indicates the total number or sum of respondents from the two groups those agreed to the idea of the items as indicators and the seventh in the same fashion indicates the sum of disagreed respondents from the two groups.

These last columns (sixth and seventh) indicate the general ratio of total respondents to those agreed and/or disagreed to the items. Accordingly, result of the analysis particularly, those in the mentioned last columns, revealed that majority of the respondents agreed except for only one (item listed on the order number 16—according to the former list), that all items are indicators of human actions as root causes of FEECI in Addis Ababa in general.

In addition to this descriptive analysis of Likert scale (‘Agree’ or ‘Dis agree’), response data analyzed in this table also used in checking or testing reliability or internal consistency of the

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

tool and/or the survey by computing Cronbach's alpha as well as to determine the relative importance (RI) values of the items.

4.5.2.2 Reliability/internal consistency of items of the survey and results

As mentioned earlier, questionnaire survey was used as supplementary method for this research. The questionnaire consists of eight (8) total items and/or questions which in general categorized in to two major groups: from question 1 up to 7 is one category that analyzed by descriptive method and question 8 by itself was the second category of the questionnaire analyzed inferentially. This second category or question 8 of the questionnaire originally contained 24 items or indicators those compiled from different reviewed literatures, observations and/or experiences. The items were proposed by the researcher to be indicators of human actions as root causes of FEECI in Addis Ababa.

These items or indicators were listed as overall summary of the survey under the categories of: technical and/or technological (planning & designing, construction, operation and/or maintenance stages of infrastructure); political (abuse of power in planning/initiatives, budget allocation/diversion, violent damage by opponent or terrorists) and cultural/behavioral (misuse, theft of infrastructures or their components) practices of stakeholders—human, with respect to infrastructure and related issues.

In the question, the respondents were requested to show their perception on the listed items in two ways: (1) to show whether they agree or disagree that the proposed items are reliable indicators of human intentional and unintentional human/infrastructural stakeholders/ actions and (2) to rank the indicators in the importance order as per their perceptions to the indicators. Accordingly, the responses of the subjects to the above ideas were separately analyzed as in table 4.7 and table 4.10. While data in table 4.10 was used for inferential analysis particularly, to test hypothesis of the research and hence computation of Spearman's correlation coefficient in which the relation among items were checked either there is a significant difference among the perception of the two groups towards the items as discussed above; whereas, table 4.7 in which the subjects were responded by two point Likert scale of : "Agree" and "Disagree" with score value of 4 and 2 respectively was further analyzed and shown as in table 4.8.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

The following common formula was used to calculate Crombach's alpha using excel spread sheet.

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum s_i^2}{s_x^2} \right) \text{----- 4.1}$$

where, k = Number of items,

S^2_i = Sum of items variance and

S^2_x = Total variance of sum of scores

Table 4.8: Reliability test by Crombach's alpha coefficient

Subjects	Items /Factors indicating human actions as root causes of FEECI																								Total item variance	
ID	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24		
1	2	4	4	2	4	2	4	4	4		4			4		2	4	4	4	4	4	4	2	4	70	Option 1
2	4	2	4	2	2	2	4	2	4		4			4		4	4	4	4	4	4	4	4	4	70	
3	4	4	4	4	4	4	4	4	4		4			4		4	4	4	4	4	4	4	4	4	80	
4	4	4	2	4	4	4	4	2	2		4			4		2	4	2	2	2	4	4	4	2	64	
5	4	4	4	4	4	4	4	4	2		4			4		4	4	4	4	4	4	4	4	4	78	
6	2	2	4	2	2	2	4	4	4		2			4		2	2	4	2	2	4	4	4	4	60	
7	4	4	4	2	4	2	2	2	4		4			4		4	2	2	2	2	2	2	4	4	60	
8	2	4	2	4	4	4	4	2	4		4			4		2	4	4	4	2	4	4	4	2	68	
9	4	2	4	4	4	4	4	4	2		4			4		2	4	4	2	4	4	4	4	4	72	
10	4	4	4	2	4	4	4	2	4		4			2		2	4	4	4	2	2	2	2	2	62	
11	4	4	2	2	2	2	4	4	2		4			4		2	2	4	2	4	2	4	4	2	60	Option 2
Variance	0.79	0.79	0.79	0.99	0.79	0.99	0.33	0.99	0.93		0.33			0.33		0.93	0.79	0.60	0.99	0.99	0.79	0.60	0.60	0.93		
	Likert Scale		Option 3										Crombach's alpha and its parameters													
	Agree	4											Items/questions/comp	20												
	Disagree	2											Sum of the item variances	15.27												
													Variance of total scores	46.41												
													Crombach's alpha	0.71												

Source: Author's summary by spread sheet data analysis

Moreover, the intention of this sub-section was checking the reliability of the tool or questionnaire survey and/or internal consistency between the items. To do so, Crombach's alpha coefficient was calculated by Excel spread sheet as in table 4.8, based on the responses data of

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

the completely responded subjects selected from two infrastructural related works of regulatory sectors, MIU and AACPCA.

Crombach’s alpha coefficient is the most frequently used technique of checking reliability and/or internal consistency of survey items in research whose value ranges from 0 to 1 and acceptable if the value is 0.7 and above though the acceptable minimum value may also be less than this depending up on field of studies. The ranges of calculated values described in literature (<https://www.statology.org/how-to-report-cronbachs-alpha/>) as in table 4.9.

Table 4.9: Interpretation of ranges of values for Crombach’s alpha coefficient

Crombach’s Alpha	Internal Consistency
$0.9 \leq \alpha$	Excellent
$0.8 \leq \alpha < 0.9$	Good
$0.7 \leq \alpha < 0.8$	Acceptable
$0.6 \leq \alpha < 0.7$	Questionable
$0.5 \leq \alpha < 0.6$	Poor
$\alpha < 0.5$	Unacceptable

Source: (<https://www.statology.org/how-to-report-cronbachs-alpha/>)

In this research, Crombach’s alpha coefficient was calculated based on the data, corresponding parameters (Number of items, Sum of items variance and Total variance of sum of scores) and options 1, 2 and 3 as shown in table 4.9.

Accordingly, all of the response data (without cleaning or excluding any of the items and/or the subjects those seem inconsistency with respect to the rest) were analyzed by excel, resulting in to the vale = 0.64 which according to table 4.9 is within the interval of $0.6 \leq \alpha < 0.7$ and ‘questionable’ accordingly. Thus, the author decided to make further test using some allowable mechanisms (removing the items that may have no or less correlation to others or the respondent with outlier data – which is far lower or far higher than others or mean data). Excel spread sheet with close observation of the data values were used to obtain the values in Options 1, 2 and 3 seen in table 4.8 as the most preferable way of modifying – increasing the value of Crombach’s alpha to the acceptable interval and hence check internal consistency or reliability of the items.

In such away, both ‘Option 1’ and ‘Option 2, (see table 4.8) involves the removal of outlier values of entire response data of the subjects or respondents. But, the only their difference is that

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

option 1 is removal of the larger outlier whereas option 2 is removal of the lower value outlier. Although their scores were different, removal of one of them equally results in to the coefficient value of $\alpha = 1.01 \approx 1$ which belongs to the interval $0.9 \leq \alpha$ and described as 'Excellent' according to table 4.9 but, the researcher did not want to choose these options for the reasons discussed later.

Again as can be seen from table 4.8, the other way was 'Option 3' which involves removal of four (4) items or questions 10,12,13 &15 of the questionnaire labeled by (Q10,Q12,Q13 and Q15) columns resulting in to the value of $\alpha = 0.71$ which according to table 4.9 be in the interval of $0.7 \leq \alpha < 0.8$ and also 'acceptable'. Since the result of this latter option is within the acceptable interval and the removal of the four items increased the alpha value to the acceptable level, it indicates that perhaps the items were redundantly included thus removing them does not affect the result rather it increases reliability. On the other hand removing the overall response data of one of the respondents as in options 1 and 2 that result in to highest value of $\alpha = 1$, was not seen useful and logically believed by the researcher as it may further reduces sample size and/or number of respondents. Not surprisingly, the size of sample or respondents of this questionnaire survey is small with respect to the requirements of statistical analysis in many literatures (limitation) but still acceptable and reliable for this research particularly in the inferential analysis of this section, because:

(1) The availability (i.e. exhaustively using of the available population—professional workers related to infrastructure in the two organizations as mentioned earlier); (2) Rate of response(i.e. most of questionnaires with incomplete response were excluded as the researcher belief in ethics of honesty and transparency and also according to several literatures (<https://militaryfamilies.psu.edu>), there is no clear cut rule that limit the percentage of rate of return and sample size but states that sample shall be representative as general rule. However, according to, the literature, depending on the 'mode of survey' or type of survey, rate of responses may be different; particularly, external it can averagely range from 10-15 % and up to 54% for in person though others also believe that response rate of above 80% is good); and (3) The importance(the tool—questioner survey was intended to be supplementary tool) for this particular research with respect to the other used main tools(face-to-face interview, field observation and case study as well as desk study). From the above argument it is clearly shown

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

that ‘Option 3’ among the other reliability checking methods, was seen to be the preferable one which resulted in to Crombach’s alpha, $\alpha = 0.71$ which in turn confirm that the items are internally consistent and the tool is reliable.

In general, Calculating Crombach’s alpha using the parameters such as: Items/questions/comp = 20, Sum of the item variances = 15.273, Variance of total scores = 46.41 those obtained after excel spread sheet processing of the raw subjects’ responses received by Likert scale of “Agree” = 4 and “Disagree” = 2 values and removing the four items indicated that the Crombach’s alpha coefficient, $\alpha = 0.71$ which interpreted as ‘acceptable’ was obtained.

That means, from the analysis the reliability of the tool (questionnaire survey) and/or internal consistency of the of the items after removing or excluding four (Q10, Q12, Q13 and Q15) of them were checked and accepted with the computed Crombach’s $\alpha = 0.71$. Thus, the former 24 items were reduced to 20 items that are consistently used in the analysis and interpretations of the data onward renumbering or labeling them as in table 4.10.

4.5.3 Inferential Analysis

As mentioned earlier, the second part of responses to the last (8th) question of the survey was analyzed as in table 4.10 as shown below. Data analyzed in this table will also be used in inferential analysis particularly, for computation of Spearman’s coefficient of correlation through hypothesis testing.

Table 4.10: Analysis summary for responses to question 8 of questionnaire for inferential part

Indicators of human actions predicted as root causes of FEECI	Average/mean number of/ records from respondents of both companies to each factor		Average Rank/value of RI	di	di ²
	MUI	AACPCA			
	Rank	Rank			
I. Human actions during Technical (Engineering and Technological) practices					
1.Planning and Designing stage					

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

1. Spontaneous origination and sprawl development/ organically without master plan/ of Addis Ababa city	3.8	12.2	8	-8.4	70.0
2. Lack/absence of feasibility study before starting any infrastructural work	3.2	8.2	6	-5.0	24.7
3. Lack/absence of inclusion input data and/or comments of concerning stakeholders particularly, community	3.8	10.0	7	-6.2	38.4
4. Incorrect/erroneous engineering computations and specifications during designing	7.6	11.3	9	-3.7	13.9
5. Lack/absence of design review and checking before starting new construction and maintenance of infrastructure works	4.6	10.3	7	-5.7	32.9
2. Construction/implementation stage					
6. Lack/absence of planning & scheduling for infrastructural works	13.2	7.2	10	6.0	36.4
7. Poor/inappropriate infrastructure construction/installation methods/techniques	7.6	5.5	7	2.1	4.4
8. Use of inferior resources(material, man power, machinery, tools and equipment) than specified and quantified for particular infrastructural works (corruption practices)	9.4	13.7	12	-4.3	18.2
9. Lack/absence of alternative utility installation methods(MUT,TT) other than the traditional open cut	8.6	11.2	10	-2.6	6.6
10. Absence/inapplicability of reliable specifications, standards, guidelines and legal frames for infrastructural and related works and Management	5	9.7	7	-4.7	21.8
3. Operation, Maintenance Disposal stages					
11. Overload/miss-utilization of infrastructures beyond their design capacity and/or their purpose	12	13.8	13	-1.8	3.4
12. Damage due to Vehicular Strike and/or other explosive accidents	15.8	17.3	17	-1.5	2.4

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

13. Lack of cooperation, coordination and communication between infrastructural companies during planning, scheduling and implementing infrastructural works & before starting any excavation works	12	6.2	9	5.8	34.0
II. Political actions/practices/leverages					
14. Lack/absence of transparent and inclusive decision making for infrastructural works	13.2	12.3	13	0.9	0.8
15. Politicians promising for provision of new infrastructure as reward of more support and future vote /election(‘pork barrel’) that will not be feasible and/or deliverable at good quality & reasonable time	15.4	11.8	14	3.6	12.7
16. Undertaking unnecessary new and reworks of infrastructures pretending it as ‘creating job opportunity’	15.2	16.5	16	-1.3	1.7
17. Unnecessary interference and urgent decision and/or making alteration by higher officials/politicians against technical requirements of infrastructure	15.8	9.3	13	6.5	41.8
18. Diversion of resource allocated for public infrastructure to other private or group advantage	15.6	13.8	15	1.8	3.1
III. Cultural and/or Behavioral practices					
19. Misuse of existing public infrastructure (e.g. as storage of construction materials, solid waste disposal place) for other purpose than the intended ones and/or poor handling of public assets	14.2	15.8	15	-1.6	2.7
20. Vandalism and/or theft acts to infrastructural assets	15.4	14.2	15	1.2	1.5
Σdi^2					371.3

Source: Author’s summary of questionnaire survey

4.5.3.1 Formulation and test of the research Hypothesis and null hypothesis

Although this sub- section was situated in this order with in the paper simply for the logical step of writing the report, it was analyzed prior to the above (Descriptive particularly, the Frequency

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Distribution) part. This is because the analysis and interpretation should be proceed after checking the reliability/internal consistency of items of the survey and ensuring the confidence of the researcher on the result which was realized by this (inferential) part of the analysis . In this sub-section of the research, hypothesis and null hypothesis of the research which is one of the procedures for computation of Spearman's correlation coefficient were formulated and tested as follows:

Null Hypothesis (Ho): There is **no significant difference** in the way **MUI and AACPCA professionals perceive the listed indicators of human actions** as root causes of frequent failure of existing infrastructure in Addis Ababa city.

Alternative Hypothesis (Ha): There is a **significant difference** in the way **MUI and AACPCA professionals perceive the listed indicators of human actions** as root causes of frequent failure of existing infrastructure in Addis Ababa city.

4.5.3.2. Calculation of Spearman's correlation coefficient

$\rho = 1 - \frac{6 \sum di^2}{N(N^2-1)}$ where, N = number of factors or items, = 20 and $\sum di^2 = 371.3$ is total sum of square of difference between ranking of two groups.

$$\rho = 1 - \frac{6 \cdot 371.3}{20(20^2-1)} = 1 - \frac{2515.2}{20 \cdot 399} = 1 - \frac{2227.8}{7980} = 1 - 0.279 = 0.72$$

Then taking level of confidence to be 95%, thus P-value at 5% =0.05, and degree of freedom $df = N-20$, at two – tailed test, check the calculated value of $\rho = 0.72$ against the critical value of the Spearman's rank correlation coefficient. Accordingly, from table annexed in appendix 4 of Naoum (2007) critical value was seen to be 0. 450 at confidence level of 95%, P -value = 5% =0.05, and degree of freedom, $df = N-20$, at two-tailed test. That means the calculated Spearman's rank correlation coefficient, $\rho = 0.72$ is greater than the critical value = 0.450 and hence the null hypothesis is rejected.

Thus, accepting alternative hypothesis, then it was concluded that there are significant differences between the ways the two groups perceive the indicators of human actions as root causes of FEECI in Addis Ababa city.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

4.5.3.3 Relative importance index (RII) and Rank of the items/indicators

Relative importance index (RII) is an important tool used to prioritize indicators rated on Likert scales. To calculate relative importance (RI), the following formula was used:

$$RI = \frac{\sum W}{A*N} \text{-----} 4.2$$

where, w is the weighting as assigned by each respondent on a scale of one to five with one implying the least and five the highest. A is the highest weight and N is the total number of the sample. RI values can be interpreted as high (H) ($0.8 \leq RI \leq 1$), high-medium (H-M) ($0.6 \leq RI \leq 0.8$), medium (M) ($0.4 \leq RI \leq 0.6$), medium-low (M-L) ($0.2 \leq RI \leq 0.4$) and low (L) ($0 \leq RI \leq 0.2$) according to Akadiri (2011), cited in Rooshdi et al.(2018) which also used in this research as indicated in the fourth column of table 4.9.

Relative importance(RI) for the items or indicators of human actions as root causes of FEECI can be determined by values directly obtained from ranking responses of the subjects (like values in 2nd, 3rd and 4th columns of table 4.8). However, RII for each of the indicators was also computed as per the equation 4.2 by excel based on the response data with Likert scale processed particularly as in table 4.7, for the sake of more accuracy and/or reliability. Although five points Likert scale based responses were commonly used in researches in general, only two points Likert scale, the "Agreed" having maximum score = 4 and "Disagree" minimum score = 2 were used in this research, with N=11 that analyzed as in table 4.7.

The following (table 4.9) was summarized from the computed relative importance by excel spread sheet in which the responses data of "Agree" with the maximum score = 4 and "Disagree" with the minimum score = 2 as mentioned above and rank as well as interpretation of items or indicators of human actions as root causes of FEECI.

Table 4.11: Relative importance (RI) of items indicating human actions as root causes of FEECI

Value of RII	Frequency of value of RI	Items belonging to the particular value of RI	Interpretation of importance level	Rank of the RI and/or the item(s)
0.86	3	7,10,11	High(H)	1 st (most important)

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

0.82	3	14,18,19	High(H)	2 nd (most important)
0.77	6	1,2,3,5,13,17	High-Medium(H-M)	3 rd (most important)
0.73	2	9 and 20	High-Medium(H-M)	4 th most important
0.68	4	6,8,15,16	High-Medium(H-M)	5 th (most important)
0.64	1	4	High-Medium(H-M)	6 th (most important)
0.59	1	12	Medium(M)	7 th (least important)

Source: Author's summary of data analysis

The analysis (RII in table 4.11 above) indicates that the RII= 0.86, 0.82, 0.77, 0.73, 0.68, 0.64 and 0.59 ranked as 1st, 2nd... and 7th respectively were obtained. The table also indicated that the first two values: 0.86 and 0.82 were distinguished as *high (H)* because they fall in the interval ($0.8 \leq RI \leq 1$) mentioned earlier. Four of the values: 0.77, 0.73, 0.68 and 0.64 were belonged to (H-M) ($0.6 \leq RI \leq 0.8$) and hence described as *high-medium (H-M)*. The lowest value of RII in this research was seen to be 0.59 which was identified as medium (M) being within the range of ($0.4 \leq RI \leq 0.6$) based on the interpretations of Akadiri (2011), cited in Rooshdi et al.(2018) .

Furthermore, the above table and/or result reveals that three indicators (of item number 7, 10, and 11) based on the order of rearranged list from as in table 4.7 to table 4.10 under question 8 of the survey were equally ranked as the 1st having RII= 0.86 and identified being the most important indicators of human actions as root causes of FEECI in Addis Ababa city.

With similar manner, *three* of the indicators (of item numbered 14, 18 and 19) having RII=0.82; *six* indicators (of item numbered 1, 2, 3, 5, 13 and 17) having RII=0.77; *two* of the indicators (of item number 9 and 20) having RII=0.73; *four* of the indicators (of item number 6, 8, 15 and 16) having RII=0.68; *one* of the indicators (of item number 4) having RII=0.64 and *one* of the indicators (of item number 12) having RII=0.59 were ranked as 2nd, 3rd, 4th, 5th, 6th and 7th and identified as the second most important, third most important, fourth most important, fifth most important, sixth most important and seventh or least most important respectively indicators of intentional (corrupted) and unintentional (erroneous) human actions, as root cause of FEECI in Addis Ababa particularly, and may also holds in other cities over the world in general.

4.6 Discussion & interpretation of results with respect to objectives of the research

Here the results were discussed and interpreted triangulating all methods used in data collection and analysis to enhance the reliability and validity of the findings of this new research with respect to its specific objectives.

4.6.1 Impacts of frequent excavations on existing infrastructures (FEECI) of Addis Ababa city

In this sub-section result of data analysis regarding impacts of FEECI were discussed and interpreted in line to two of the research questions (1 and 2) and the first specific objective of the research respectively.

❖ **Objective one:** ‘To assess economic/sustainability impacts of frequent excavations to existing infrastructure of Addis Ababa city’

The two (among the research questions) related to this first objective are: (1) what type of impacts imposed by frequent excavations on existing infrastructures of Addis Ababa city? and (2) what are the attributions and/or rank of utility companies to such repetition of excavations? To answer these questions and achieve this specific objective, more qualitative and fewer quantitative data were collected by field observation and face to-face interview that were analyzed qualitatively as dominant technique and also quantitatively. Analysis of previous literatures, observation and participants’ response data indicate that excavation in general and FEECI in particular, have been imposed economic and/or sustainability impacts to international cities in general and particularly to Addis Ababa city.

Economic and/or Sustainability impacts: is a collective of different impacts including but not limited to: Rework/repairing costs, Operational costs, Societal costs—health & safety/convenience impacts, and Environmental as well as aesthetical impacts which can be called in acronym as ‘ROSE’ as also seen earlier. All of these impacts were analyzed and discussed in this research with main focus on repair/rework costs/impacts as follows:

Repair/rework costs of city infrastructure: regarding this, analysis of data revealed that FEECI imposes considerable economic/sustainable impacts/ in terms of direct costs of material, labor, machinery and/or tools for construction or reinstatement of the excavated parts of the

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

street (roadways and walkways) as already discussed earlier in table 4.3 and indicated below in table 4.12.

The quantitative data in both tables were obtained from AACRA both showing the economic impacts/costs (in terms of money by Ethiopian Birr—ETB) of frequent repairing and/or reworking of city infrastructures (streets and utilities) of Addis Ababa City.

Table 4.12: Economic (Monetized infrastructure repair) impacts of FEECI in Addis Ababa City

Observation	Frequency of excavations/Rework	Economic Impact(repair costs, in ETB)
1	2	21,730.51
2	3	35,842.80
3	1	20,630.40
4	3	56,451.86
5	4	56,451.86
6	6	230,297.74
7	2	5,662.72
8	3	353,594.89
9	3	23,177.23
10	2	67,343.21
11	3	144,159.00
12	2	25,433.24
13	2	2,552.54
14	2	7,643.98
15	3	2,552.54
16	9	1,827,842.85

Sours: AACRA (processed by the author)

Operational costs/impacts: this consists of indirect impacts such as revenue losses due to services interruption (access to business centers, power outages, internet and water supply) etc., all of which increases costs of functioning and/or decreases expected income, like those identified in previous literatures. The qualitative data collected by field observation and interview revealed that there were infrastructure damages, traffic congestion, business interruptions and hence income loss as well as loss of resources in general due to frequent excavation with in the streets of the city which collectively known as operational costs or impacts. That means FEECI results in to high cost of operation plus loss of income due to damaged and/or inefficient infrastructure.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Societal (health & safety/convenience) impacts: expressing disease, injury and death impacts in terms of money is difficult in general. Quantifying them in terms of money is not in the scope of this research, In this case also, only qualitative data was obtained via field observation and face-to-face interview. Field observation data and its analysis revealed that the excavation particularly, the one frequently undertaken to the existing infrastructure (streets, utility assets and greeneries) of Addis Ababa city had been imposing health & safety/convenience, aesthetic and economic and/or sustainability impacts as a whole.

Evidently, figure 4.16 below (captured during field observation) indicates that how much it is difficult and risky for the elderly mother (fig.4 .16(a)), a disabled wheel chaired man (Fig.4.16 (b)) and even for pedestrians that were not disable in terms of safety and/or convenience, to pass across the trench excavated along walkway of the main road in front of AAiT on the side of National Museum as well as on the walkway of the road segment between “Degol” and Menilik squares or at the street near ‘Adwa 00 or Museum’ (fig 4.16 (c)).



(a) Elderly mother to cross excavated trench



(b) Disabled and wheel chaired man facing trench ahead



(c) Inconvenience & risky travel to pedestrian and loss of transactions to business firms due to excavated walkway

Figure 4.16: Impact of frequent excavations on safety/ convenience of users (captured by author)

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

In addition to figure 4.16, most or 70% (i.e. seven among the observed ten excavation events) of the situations analyzed in the above figures (fig.4.2 to fig.4.11) indicate that there were chance of exposure of workers and/or users of the street to unsafe and inconvenient conditions as well as near miss (high chance but not occurred accident) electric shock as in the case of events where electric cable was seen exposed during the excavation or street work at Adey Ababa. Analysis of both the questionnaire and interview data also indicate that there has been accidents, injuries, death and health problem due to odor and/or dust particles retain on surface after overflow of sewerages due to frequent and early failure of infrastructure and hence frequent excavations or vice versa in the city.

Result of questionnaire analysis (table 4.5, fig 4.13 and fig.4.14 as well fig 4.13 in particular, indicated that, most (64%) of the respondents strongly agreed to the proposition ‘Frequent excavations are common practice in Addis Ababa’ provided on question 1 of the questionnaire. The same table and fig.4.14 on the other hand, reveals that FECCI has different impacts (options provided in the question number 2 of the question including ‘health’; moreover, almost all (91%) of the subjects responded that FECCI in Addis Ababa imposes impact to all of the listed aspects.

Environmental and/or Aesthetics impacts: regarding impacts of FECCI on aesthetics and environment, it can be obviously seen that there would be inevitably unclean environment, dusty and muddy in this case based on availability rain. Such events not only affect the quality of users’ life, but also resulted in to irregular, rough and disturbed appearance of streets and hence that of city at whole. Figure 4.17 clearly shows that the muddy (figure 4.17 (a)) when raining and dusty and/or rough (figure 4.17 (b)) conditions of asphalt road in Akaki Kality Sub-city, Woreda 05, particularly located at “Berta sefer” due to dump trucks hauling cart away material from other construction site elsewhere along the road.



(a) Rough asphalt road surface due to cart away material (b) Muddy asphalt surface due to cart a way

Fig.4.17: Rough, dusty and muddy surface of asphalt road due to earth work (captured by author)

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

In addition to the above illustration, the figures described earlier and physical profile at most of Addis Ababa streets particularly walkways, reveal that FEECI have imposed aesthetic impacts. Results of both interview and questionnaire surveys also revealed that, early and frequent failure, hence frequent excavations and vice versa, of existing infrastructure of Addis Ababa made the streets of the city and/or almost all environment of the city rough, dusty/muddy. The over hanged utility lines installation pattern also look like ‘spider web’ and hence unpleasant and unattractive though the city is large diplomatic and expected to be tourist destination in general, which in turn affects productivity of individuals and income generation (economy) indirectly.

Fig.4.18 below for instance, indicates the damaged utility lines and walkaways as well difficulties of access to business centers due to excavation works. The first three pictures in the figure indicate excavation work undertaken at Arada Sub-city ‘woreda’ 01 for construction of recreational places along the river passing there after displacing residents within the ‘buffer zone’ where utility lines(fig.4.18(a) one of not identified cable,(b) potable water pipe and (c) fiber optics were seen damaged .The next two figures:fig.4.18 (d) and (e) indicate the difficulties of access to business centers such as café, supermarkets and pharmacies due to excavated walkways in front of them along the street. Several authors identified previously the occurrence of such impacts (i.e. they are expected and/or inevitable) however; they did not consider the frequency. The difference is that, magnitude of the total impacts increase proportional to the frequency of the same or different types of excavations and/or reworks within city that was overlooked by almost all of the scholars

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets



(a) Damaged invisible utility line during excavation (b) wastage of scarce water due to damaged pipe (c) damaged fibre optics



(d) Inconvenient travel and access to shopping centers (e) loss of customer and/or income to firms due to excavated trench
Fig.4.18: Indirect economic impacts of repeated excavations to existing city infrastructure (captured by author on 25/9/2023)

4.6.2 Root causes of frequent excavations to existing infrastructure of Addis Ababa city

❖ **Objective two:** ‘ To identify root causes of frequent excavations relevant to existing infrastructure of Addis Ababa city’

The other two questions of the research (question 32 & 4) that are related to this second specific objective of the research are: ‘Why excavations frequently undertaken to existing infrastructure (streets, greenery & utilities) of the city?’ and ‘What are the manifesting factors for root causes of FEECI & their respective importance?’

From analysis of field observation data, it was identified that frequent failure of city infrastructures particularly, street elements—roadways, walkways, medians, curb stones, greeneries, drainage systems and utility assets had been occurring due to:

❖ **Technical:** poor planning; poor design and construction which include conditions such as in (fig.4.3,4.5,4.6,4.7 and fig.4.9) events located at ‘Labu’, AAUCNCS, ‘Berta Sefer’, ‘Ras Desta Damte Street’ near CBE head quarter and right lane of ‘Serra Leon Street’; maintenance and/or repairing; poor planning/scheduling and integration of stakeholders—poor communication and management.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

- ❖ **Political and/or Technical:** interference of higher government officials in technical through their initiatives only in the political point of views, as political leverage and/or ‘pork barrel’ like the one stated by Parkin and Sharma, (1999) , for example the repeated excavations (both in terms of time and location) undertaken by ETC and AACRA, as per the analysis include(fig.4.2,4.4 , 4.8 and fig.4.16) events at ‘Adwa street’, ‘Tito Street’ near DBE and ‘Churchill Avenue’ and ‘King George VI street’ the one near national museum all of which also related to the then poor planning and/or design of existing infrastructure.
- ❖ **Cultural/behavioral:** some of the analyses results (fig.4.10, 11 and 16) events undertaken at left lane of “Serra Leon Street” and “Adey Ababa” T-junction, revealed that failure of drainage system—being clogged by solid wastes hence upward or surface flow of the contaminated drainage damages road surface in addition to its effect on health as the odor and the contamination through body or internal organs contact. Moreover, the observation reveals that frequent excavations are due to such causes as the damaged road surfaces need to be repaired. From the above discussion, field observation analysis results clearly revealed that 5(45.45%), 4(36.36) and 2(18.18) of the included or discussed infrastructural rework events attribute to technical, political and/or technical and Cultural/behavioral practices respectively, that human/stakeholders of infrastructure issues intentionally (corruptly) or unintentionally (erroneously) undertake.

Regarding root causes of early and frequent failure hence FEECI or vice versa to existing city infrastructure of Addis Ababa, analysis of questionnaire survey as supplementary to other tools also revealed that technical, technological, political and cultural/behavioral practices of stakeholders are the categories under which the indicators prioritized earlier according to their RI were listed and/or proposed. Similarly, interview analysis results indicate that in one way or another, the indicator of human—infrastructural stakeholders’ actions in Addis Ababa were seen to be categorized as technical and technological, political and cultural/behavioral practices. The following component pictures of figure 4.19 vividly indicate culture of the community in terms of usage, handling of existing city infrastructure and solid waste disposal in general.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets



(a) Ditch blocked by solid wastes



(b) Verge & solid waste



(c) Clogged & damaged drainage line



(d) Solid wastes (plastic bottle & mud)



(e) Inletting slaughtered animal byproducts to drainage system



(f) dumping construction materials on walkways

Fig.4.19: Poor culture of community /misusing of infrastructure in Addis Ababa (captured by author)

The first two pictures (fig.4.19 a & b) indicate that open channel clogged by both solid wastes and gray water as well as grass verge which all together causing functional failure to the drainage system. Fig.4.19(c) indicates damaged cover of drainage system in which solid waste particularly, rubber inserted clogging the system. On the other hand, fig.4.19 (d) revealed slurry of dirt material and solid wastes removed from drainage system at Lideta sub-city, particularly at “Mexico” square as the annual maintenance activity of AACRA.

Fig.4.19 (e) reveals dogs feeding on the shaded blood of animal slaughtered for meat during Ethiopian New Year holiday at Arada sub-city woreda 01 which was flowed in to the drainage system. This is one of the indicators of in appropriate culture or behavior of the community regarding handling of public infrastructure and waste disposal. The last picture or fig.4.19 (f) shows dumped construction material particularly, sand and aggregate at Arad sub-city on walkway of the newly widened street or boulevard, Churchill Avenue.

These in turn clearly revealed that intentional and unintentional human actions through technical, political and cultural/behavioral practices are root causes of the FECCI in Addis Ababa city. Apart from these root causes (those identified via field observations) and indicators proposed in

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

survey questions, several new findings (root causes) of early and frequent failures and hence repeated excavations or reworks were also investigated (given by respondents) to be:

1. “The ups and downs or through and valley nature of the topology of Addis Ababa city that affect the efficiency of AAWSA’s water supply and sewerage as well as AACRA’s drainage system”,
2. “Poverty or limited resources of the country to construct or install all necessary infrastructure of the city at the same working time(schedule) and budget allocation”,

4.6.3 Developing/Modifying estimation mechanism for impacts of FEECI

Here is where the result of analysis was discussed with respect to achievement of the third specific objective and answering of related questions of the research. The research questions (question 5 & 6) are: ‘How can the existing excavation impacts estimation techniques be modified for enhanced computation and decision making?’ & ‘Do frequencies of excavations and/or the causes contribute to magnitude of impacts?’ While the objective is as follows, it will be achieved and the questions will be answered as in the following discussion.

Objective three: ‘To develop empirical equation with regression model for infrastructural rework impact/cost estimation’.

As mentioned earlier, several authors (Makana et al., 2019; Jung and Sinha, 2007; Hunt et al., 2014) tried to develop tools, and equations used to estimate impacts and/or costs of infrastructural related works in general. Though they developed different models, almost all of them are based in general, on the social, environmental and economic impacts of street works. In these previous literatures, time element of the models was not considered in terms of frequency or repetition of the excavations or infrastructural rework. This new mechanism or empirical equation was developed to fill such gap during estimation of the overall economic and/or sustainability impacts as follows:

$I_t = I_e + \sum (I_i * f_i)$ as expressed earlier in equation 2.4, is a general empirical equation where, I_t is total impacts, I_e is the expected or inevitable impacts of infrastructure maintenance or repairing works, I_i is individual or all types of impacts of frequent excavations or rework(repairing cost of infrastructure, operational costs, Societal(health & safety/convenience impacts and environmental and/or aesthetic impacts, and f_i is the frequency of each type of

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

impact within a given period of time or the repetition of repairing works beyond the expected and/or planned one within the predetermined period of time say for example once a year.

This general and new empirical equation of infrastructural work impacts estimation mechanism can also be further modeled by regression equation as:

$$I_{Te/s} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon \text{ ----- 4.3}$$

where, $I_{Te/s}$ = Total economic and/or sustainability impacts of frequent infrastructure works (dependent variable of the model),

X_i = independent variables (Repair/rework costs, Operational costs, Societal (health & safety/convenience impacts and Environmental and/or aesthetic impacts —ROSE)

β_0 = intercept

β_i = coefficient of the independent variables (predictors) X_i

ε = ‘error term’ or ‘noise term’ – to incorporate hidden independent variables

In this study repairing cost data only used in simple regression model as in equation 4.4 to partially validate the above general regression model. However, full validation of this proposed multiple regression model was left for further researchers. This is because collection and analysis of quantitative data for three of the proposed independent variables: operational costs, societal (health & safety/convenience) impacts and environmental and/or aesthetic impacts as well their frequency in terms of money, is broad and cannot be covered here as it is beyond the scope of this research.

As just stated above, to indicate the economic impact of frequent excavations on the existing infrastructure of Addis Ababa city, this research partially validated the empirical equation and/or simple regression. To accomplish this (to show the relationship between frequent excavation/infrastructural reworks as independent variable and repairing cost—economic/sustainability impact in terms of money as dependent variable), the following regression model was developed and validated in the way of achieving the third specific objective and answering the correspondent above questions of the research as follows:

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

$$I_{rc} = \beta_0 + \beta_1 X_1 \text{ ----- } 4.4$$

where, I_{rc} = impacts of frequent infrastructure repair/ rework only (dependent variable of the model)

β_0 = intercept

X_1 = independent variable (Frequency of Excavations or infrastructural rework

β_1 = coefficient of the independent variable

To validate this model, the following hypothesis was tested with the regression analysis of the data presented in table 4.12 by excel Add-ins:

Null Hypothesis (H_0): Frequent excavations to existing city infrastructure, FECCI of Addis Ababa, have negative economic impact (do not increase the magnitude of infrastructural repairing cost)

Alternative Hypothesis (H_a): Frequent excavations to existing city infrastructure, FECCI of Addis Ababa, has economic impact (increase repairing cost of infrastructure)

As also stated above, the following results were obtained from the regression analysis of data from records of AACRA presented in table 4.12 at degree of freedom, $df = 16$ and confidence level of 95% and/or $P < 0.05$.

(a)						
SUMMARY OUTPUT						
<i>Regression Statistics</i>						
Multiple R	0.859639871					
R Square	0.738980708					
Adjusted R Square	0.720336473					
Standard Error	237890.0381					
Observations	16					
(b)						
ANOVA						
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>	
Regression	1	2.24306E+12	2.24306E+12	39.63588218	1.9695E-05	
Residual	14	7.92283E+11	56591670227			
Total	15	3.03534E+12				
(c)						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	-446742.1323	115974.2998	-3.852078719	0.001760318	-695482.2667	-198001.9979
Frequency of excavations	200584.8298	31860.59045	6.29570347	1.9695E-05	132250.6596	268919.0001

Figure 4.20: Excel Add-ins regression analysis results of frequent excavations to existing infrastructure of Addis Ababa city

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

As can be seen from the above figure, regression analysis results include:

- ($F = 39.64$, $P < 1.9695E-05 = 0.0001$) — overall regression is significant,
- (t -test for Intercept = -3.852 and at $P < 0.002$ hence significant);
- (t -test for ‘Frequency of excavations’— the independent variable, = 6.295 at $P < 1.9695E-05 = 0.0001$);
- ($R^2 = 0.73898 = 0.74$)—“*Coefficient of determination or measure of explained variation*” which in this case indicates that 74 % of the total variation in repair cost (I_{rc}) is explained by the regression or the model;
- Standard Error (measure of *unexplained variation*) which was found to be **237890.04**

These in general, indicating the overall regression is statically significant at P -value < 0.05 giving the estimator model:

$$I_{rc} = - 446742.13 + 200584.83X_1 \text{ ----- } 4.5$$

From the model it can be seen that intercept, $\beta_0 = - 446742.13$ and coefficient of X_1 , (the independent variable), $\beta_1 = 200584.83$. Based on this evidence therefore, the null hypothesis was rejected (accepting alternative hypothesis).

That means, the regression test indicates that, there is significant relationship between the independent variable—frequency of excavation or repeated infrastructural works & dependent variable—economic impact of frequent repair costs of existing infrastructure of Addis Ababa.

Evidently, objective three of the research was achieved and as well as those related questions were also answered based on regression test results of the quantitative secondary data of infrastructural rework or repairing cost obtained from AACRA.

4.6.4 Validation for Imperial equation of FEECI impacts/cost estimation

As discussed earlier, general empirical and specific regression models used to estimate impacts and/or costs of FEECI were developed.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Table 4.13: Collected rework/repair costs as compensation for different excavation to road elements in 2015 E.C owing AACRA

No.	Type of works/excavations	Damage in terms of money		
		Number of events in 12 month	Costs of reworks in 12 month	up-to-date/at the end of the year/
1	To connect storm water line	65	405,109.05	405,109
2	To install potable water line	79	1,240,364.26	1,240,364
3	Compensation for cutting of road by infrastructure Authorities	36	6,032,171.13	6,032,171
4	Cut to road to connect sewer lines of AAWSA	92	869,999.57	870,000
5	To open or construct missed access road	66	1,850,572.52	1,850,573
6	Penalty for dumping construction material on street	4	158,881.38	158,881
7	To remove concrete retaining wall	-	-	-
8	To remove existing and pave walkway by improved tile	6	289,339.89	289,340
9	Service charge	-	-	0
10	Compensation for damaged walkway during relocation of power line	-	-	-
11	Cutting of street light cable/damage	-	-	-
12	To install cable	5	65,277.37	65,277.37
13	To investigate and/or unclog manhole	6	5,166.93	5,166.93
Total		359	10,916,882	10,916,882

Source :(AACRA processed by the author)

To validate the empirical equation and/or model, data received from AACRA (table 4.13 and table 4.14) were used in combination in the following sense:

1. It is assumed that although the impacts or costs of frequent excavations to existing city infrastructure can be transacted among different stakeholders (be it federal, regional intra and inter-sectoral), the overall economic or sustainability impacts commonly touch all, affecting the city or the country at all.
2. The empirical equation or model of frequent excavation and/or infrastructural rework costs is ' $I_t = I_e + \sum (I_i * f_i)$ '. In this, the first term, I_e is expected infrastructure repair and/or maintenance cost within specified period of time say, annual. Thus, for validation of this empirical equation, AACRA's annual (2015 E.C fiscal year) budget plan (see table 4.14) for road maintenance and/or repair that was allocated to be **971,917,718.75** ETB was taken as I_e .
3. The term ' $\sum (I_i * f_i)$ ' which appeared in the above empirical equation is summation of individual or each impacts or costs of rework/repeated excavations, I_i to existing city

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

infrastructure (which may include but not limited to repair, societal and environmental impacts or costs if any and available monetized one) multiplied by corresponding frequency, f_i .

Table 4.14: Annual (2015 E.C fiscal year) budget plan of AACRA for infrastructure maintenance costs

No.	Maintenance Type	Unit	Annual Plan
1	Asphalt road	Birr	396,858,313.81
2	Drainage line	Birr	99,002,784.91
3	Bridge & Retaining wall	Birr	31,428,136.00
3	Gravel(access)road	Birr	49,917,486.81
5	Walkway and curb stone	Birr	229,653,773.31
6	Emergency & ancillary works	Birr	165,057,224.00
Total sum			971,917,718.85

(Source: AACRA own force road maintenance Directorate 2015 fiscal year performance report extracted by author)

As such, only average repairing costs and frequencies (10,916,882 ETB/12 months =909,740.17ETB per month and 359 excavation or rework events/12 months = 29.917≈30 street work events per month or at least one excavation event per day) manipulating data obtained from table 4.14 was used for this purpose as quantification or monetizing operational, societal, and environmental impacts is beyond the scope of this new research. Accordingly, the model is validated giving = **999,209,941.25 ETB** inserting the above values in ‘ $I_t = I_e + \sum (I_i * f_i)$ ’ as indicated below.

$$I_t = 971,917,718.75 + (909,740.17*30) =971,917,718.75+27,292,222.5 = \mathbf{999,209,941.25 ETB.}$$

This means that, annual budget of infrastructural maintenance and/or repairing costs increase with increase of frequency for street works though the maintenance cost is considered as expected rather than being impact. However, such costs and other that may be occur as a result of FECCI even if not quantified here in general, negatively affect economic and sustainability aspects of the city as well as the country at all as they increase expenditures rather than revenue.

4.7 Guidelines to avoid/minimize frequent excavations/infrastructural reworks

Because of the overarching character of city and infrastructure, guidelines regarding development and management of city infrastructure over the life cycle (from conception to the

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

maintenance and/or disposal stages) have to be available. Therefore, in order to fill the gaps regarding unavailability and poor application of infrastructure related guidelines, the researcher inquired both in research question and survey data collection particularly, during interviewing respondents of the selected infrastructure companies. Hereby, objective four of the research, *‘to develop basic tool for infrastructural sectors, policy makers and academicians used as common guidelines and reference’* and the research question related to this objective which asks ‘How can stakeholders avoid and/or minimize these causes and impacts?’ were achieved and answered respectively.

4.7.1 Suggestions/guidelines input/ from AACAUBGDB respondent

Acknowledging the importance and/or inevitability of excavation due to the need for upgrading, repairing the existing and/or construction of new city infrastructure, and need to avoid and/or minimize frequent excavations or infrastructural reworks, as well as subsequent impacts, the respondent suggested the following:

- “There shall be robust study before decision making & implementing infrastructural work;
- All infrastructural stakeholders shall work with coordination and cooperation;
- Most of the city areas and/or centers particularly, the ‘slum’ areas such as autobus tera, Merkato and the like shall be redeveloped/renewed appropriately compensating and/or restoring the local community with participatory and transparent procedures.
- Excavation shall not be started immediately before / during Ethiopian rainy season ‘Kiremt’;
- The inevitably excavated pit or trench have to be reinstated or protected immediately, to avoid subsequent health and safety and/or convenience impacts and ;
- Improving quality of infrastructure works by appropriate supervisions and controlling over the corrupted actions possibly occurred in different ways and stages”.

4.7.2 Suggestions/guidelines input/ from AACRA respondents

- Using alternative technologies for utility installation and location
- Complete and detail investigation of problems or infrastructural failure before undertaking any maintenance or repairing works
- Strict integration of infrastructure companies

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

4.7.3 Suggestions/guidelines input/ from AAWSA respondents

Respondents from AAWSA suggested that the following are important and can be guidelines to avoid and/or minimize frequent excavations or reworks within Addis Ababa city:

- ❖ “Strict integration of infrastructural stakeholders,
- ❖ Using available technologies for infrastructure works,
- ❖ Controlling quality of material and work,
- ❖ Deployment of skilled man power and
- ❖ Appropriate planning and designing”
- ✦ “All concerning stakeholders right from now should:-use technology,
- ✦ Training/educating community to change attitude and cultures towards infrastructure,
- ✦ Working in integration and
- ✦ Establishing planned new city then reconstructing this old city”.
- ✦ “Strict integration of infrastructural stakeholders,
- ✦ Using technologies for infrastructure works,
- ✦ Controlling quality of material and work,
- ✦ Deployment of skilled man power and
- ✦ Appropriate planning and designing infrastructures”

4.7.4 Suggestions/guidelines input from EEU respondents

- The respondent suggested community has to be aware of that infrastructures are common goods.
- Having reliable and commonly scheduled budget and/or fund for infrastructure companies

4.7.5 Suggestions/guidelines input from ETC respondent

The respondent from Ethio-telecom (ETC) strictly and repeatedly suggested the following for the questions asked by the researcher what to do to avoid or minimize such frequent excavations or infrastructural reworks within Addis Ababa:

- “Political issues and goal should be separated from the technical requirements of infrastructure;

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

- There shall not be interference and sudden enforcement to execute incompletely planned, designed and scheduled project;
- If involvement of politician in a management of a given infrastructural project, he/she shall come with a best understanding and if possible with technical knowledge and skill; in-depth study, forecasted and complete plan and design of the project;
- There shall be integration, common understanding & feeling, responsibility and commonly shared full information and/or documents of projects among the stakeholders from the conception to the end of the infrastructure project”.

4.7.6 Summarized or augmented respondents’ suggestions as basic input for common guidelines

1. Change attitude and ethical status of stake holders and/or the whole community via any means of communications(main and social media etc.) towards public infrastructure ownership, usage and handling; teaching and/or making awareness on the badness and/or illegality of the following political & behavioral/cultural practices/ human actions and their manifestations:

❖ Corruption and related practices

- ‘Pork barrel’ or “Pork barrel politics is the practice of an elected official leveraging their vote to gain valuable concessions in exchange for political support, such as securing valuable government contracts or infrastructure projects for their constituents”(https://www.investopedia.com/ask/answers/042115/what-are-some-examples-pork-barrel-politics-united-states.asp)
- Diversion of ‘earmarked’/allocated public resources for private or groups’ advantage

❖ Terrorism and/or Vandalism practices

- Vandalizing (damaging or destroying) existing infrastructure in part or in whole

❖ Bad culture and behavior on infrastructure handling/usage

- Misuse of the public infrastructure: for dumping solid wastes, construction materials & machineries etc.
- Stealing the parts and/or whole of infrastructures
- Lack of ownership feeling and responsibility for infrastructures

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

2. Build appropriate capacity (knowledge & skill) of technical forces: engineering team and non-engineering—politically involving managers and laborers to avoid and/or minimize to the possible minimum extent errors occurring during the following *technical & political* practices:
 - Conception (strategic planning and design) stages of urban/city and their infrastructures,
 - Implementation (construction/execution/installation) stages,
 - Operation (proper using, maintenance, repairing) stages,
 - Disposal and/or upgrading (demolish and removal of abandoned, renovation/modification/change) of existing infrastructure
3. Provide clear, complete and realistic rules, regulations, standard and specifications for all and every units of works related to infrastructures
4. Use alternative methods and technologies for utility asset location /installation after cost-benefit analysis
5. Use all available models of estimating impacts/costs (in terms of money) of inevitable excavation activities and the following empirical equation and/or model (developed/modified by the researcher) for estimation of impacts due to frequent open cut/excavations:
$$I_t = I_e + \sum (I_i * f_i),$$
 where all parameters are as defined earlier.
6. Enact and strictly implement legal enforcements against any illegal (intentionally committed) human actions on infrastructure in whatever practice it is.

4.8 Findings of the research

4.8.1. Impacts of FEECI in Addis Ababa

Analysis of all of the research data (from field observation, face-to-face interview and questionnaire) revealed that FEECI imposed economic and/or sustainability impacts on the Addis Ababa city and its residents as well as visitors in terms of:

Repair costs: - direct *costs* (extra costs for repairing of frequently failing of existing infrastructures) as the result of data analysis indicated in table 4.1, fig.4.7 to 11– the case studies of the observed excavations undertaken within the city, Addis Ababa.

Operational costs: - *indirect costs* (traffic congestion, losses of business) incomes, etc.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Societal (Health and Safety/convenience): - difficulty of crossing excavated trench to pedestrians mainly elders and disabled users (see fig.4.16) and other such as exposure to vehicular accident,

Environmental and/or Aesthetics: - rough, dusty, muddy streets and city as well as unattractive appearance of infrastructures and hence city as revealed in in fig.4.17 and other figures in this research,

4.8.2 Root Causes of FEECI in Addis Ababa

It also indicated that the root causes of FEECI in Addis Ababa were intentional or conscious (corrupted) and unintentional (erroneous) human/infrastructural stakeholders/actions. Those actions were committed by different stakeholders of the city infrastructure: politician and professionals involving in planning and design, professionals and non-professionals involving in construction, maintenance or repairing and community—user of the infrastructure who may involves in one or more of the following practices:

Technical and technological:- lack of feasibility study; poor planning and designing, poor construction, maintenance ,repairing of infrastructure; poor workmanship, poor supervision; lack or inapplicability of alternative solutions or technology, standards, guidelines etc.as revealed earlier in the analysis section mainly tables 4.5,4.6,4.7,4.10 & 4.11.

Political:- regarding this, the analysis of data mainly from interviewees and both the field observations and questionnaires revealed that the politicians/government higher officials’ sudden proposal or initiation of new projects, relocations of existing infrastructures, interference in technical decisions, the intention of crating job opportunity, and misuse/diversion of resources allocated for particular project to those they politically giving priority. Terrorism, war and violence due to opposing to political groups also identified to be political related root causes.

Cultural/Behavioral: - analysis of mainly field observations (fig.4.10 (a) & (b), fig.4.17) and responses of interviewees as well as the questionnaire indicated that there are cultures of misusing existing city infrastructure in the city. Particularly ,dumping construction materials on roadways and/or walkways, throwing or disposing solid wastes such as plastic bottles, rubber/tyres, dead animals and byproducts of slaughtered animals etc. in drainage system which

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

interns clog the systems resulting in to up flowing or back flowing and hence failure of road surfaces were common in Addis Ababa. There are also stealing parts of utilities leading to failure hence causing rework. These were manifested by the indicators analyzed as in table 4.7 and of relative importance (RI) were determined as in table 4.11 in analyses section.

4.8.3 Modification/redevelopment of impact estimation mechanism in consideration of FEECI

The empirical equation and/or FEECI impacts estimation technique, ' $I_t = I_e + \sum (I_i * f_i)$ ' as general, was developed by the author of this new research modifying the existing notion and equations previously introduced by former authors particularly, Hunt et al. (2014) who developed ' $C_{SUSTAINABILITY} = C_{ECONOMIC (DIRECT+INDIRECT)} + C_{SOCIAL} + C_{ENVIRONMENTAL}$ ' to estimate "cost of sustainability" and Jung and Sinha(2007) who develop ' $TC_{OC} = C_{DIRECT} + C_{SOCIAL} + C_{ENVIRONMENTAL} + C_{OTHER FACTORS}$ ' and ' $TC_{TT} = C_{DIRECT} + C_{SOCIAL} + C_{ENVIRONMENTAL} + C_{OTHER FACTORS}$ ' to compute and compare costs of "Open cut" and "Costs of trenchless technology" for decision making as discussed in section 2.6.2.1 of this research. Both multiple (equation 4.3) and simple regression models (equation 4.4 and 4.5) were also developed to test the hypothesis and validate the empirical equation.

4.8.4 Development/provision of foundational material for common guidelines of infrastructure

This research paper itself as mentioned earlier particularly, the suggestions and augmented imputes of the researcher discussed in section 4.7 of this research was found to be a foundational input material for development of robust and common guidelines of infrastructural related issues may be used by policy makers, infrastructural companies and academicians.

4.8.5 New findings of the research

New findings referred to the findings of the research that were not found yet by previous researchers and the one that were originated from the respondents as extra responses other than those expected or obtained based on the asked closed ended questions of the survey and field observation. Accordingly, this research came with the following new and/or additional findings:

1. Root causes of FEECI in Addis Ababa City other than proposed in questionnaire:

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

1.1 The ups and downs or through and valley nature of the topology of Addis Ababa city that affect the efficiency of AAWSA's water supply and sewerage and AACRA's drainage system.

1.2. Poverty or limited resources of the country to construct or install all necessary infrastructure of the city by the same working schedule and budget allocation.

2. Rank of infrastructural companies in terms of undertaking repetitive excavations or rework on existing infrastructure of Addis Ababa. Accordingly, it was identified that AACRA and ETC were ranked as the most frequently undertaking excavations having equal mode =1st, AAWSA the second, having two modes but because the mode of EEU was recorded to be third, automatically it was rationale that to rank AAWSA as the second most, EEU the third most, and AACAU BGDB as the fifth or rarely undertaking excavations to existing city infrastructure of Addis Ababa (see table.4.2) which was the result of interview data.

3. Development of empirical equation ($I_t = I_e + \sum (I_i * f_i)$) as '*Modified mechanism*'; ($I_{Te/s} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon$) '*as alternative multiple regression model*' and ($I_{rc} = -446742.13 + 200584.83 X_1$) as '*simple regression model*' for estimating impacts of FECCI in Addis Ababa.

Objective four: '*To provide basic guidelines and/or reference material for infrastructural stakeholders for efficient services and further work on future gaps of related problems*'

Up to this stage, (accomplishment of this research document) as the whole and some lists of guidelines presented in the earlier section and sub-sections, was the last but not least objectives of this research. During the process of this research work, relevant information and several findings were achieved and all together formed not only this complete research paper, but also document that identified root causes of FECC and subsequent impacts in Addis Ababa city as well more or less tried to put basic foundation for infrastructural stakeholders (infrastructure sectors and/or utility companies, policy makers) and academicians. That means, accomplishment of this thesis paper is not merely fulfillment for partial requirement of master's degree; beyond this, it was also to solve practical problem by which the seventh question ('How can and what shall stakeholders use to avoid and /or minimize root causes & impacts of FECCI?') and the fourth objective of this research were answered and achieved respectively.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Literatures argued that because infrastructure and city are important economic input, environments, particularly city is highly dependent on infrastructure, as well as due to its nature or characteristics, infrastructure can affect one's economy negatively and/or positively; Thus appropriate considerations shall be given to the sector and related issues. There are local, national and international complicated problems regarding the existence and properly functioning of one's infrastructure system particularly, that of urban or city area. Therefore, to solve such problems and enhance maintain and/or improve the welfares of citizens, undertaking more and more researches are necessary.

This academic and at the same time problem solving research, was undertaken to investigate the main causes of frequent excavations to existing infrastructures particularly, streets and utility assets of Addis Ababa city. To achieve the main and specific objectives of this research, different methods such as field observation, face-to-face interview with participants from infrastructural companies and a short supplementary questionnaire survey were as well as fewer case studies were used. The data were analyzed separately and discussed triangulating results from all of the methods that helped enhancing the reliability and validity of the findings. From the findings of the research the following were concluded:

1. Frequent excavations to existing infrastructure were commonly noticed in Addis Ababa city,
2. Analyses of data from all involved methods revealed that such frequent excavations have been imposed impacts on community and individuals in terms of health & safety, aesthetics of the city and economy or sustainability point of view. The results indicate, health and safety—possibility of injury, death due to exposure to vehicular accident and/or inconvenience—difficulty of movement for old mother and wheel chaired disabled man, environmental pollution hence probable health problems due to dust and odor from up flowing or back flowing of gray and contaminated storm water due to clogged drainage and sewers system. The results also indicated that FECCI imposed aesthetic impact on the road and walkways of the street and the appearance of the city as the whole, which in turns affect the income from tourist attraction. The result further indicated that FECCI imposed indirect

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

costs (traffic congestions and loss of income for business firms resulted from services interruptions due to damaged utilities and access to business centers) and direct costs of repairing and/or reinstatement of failed roadways, drainage systems and walkways as indicated in table 4.3. Infrastructural companies were ranked in frequency of their execution of infrastructural rework as in table 4. 2.

3. The main causes of those frequent failure of infrastructures and hence frequent excavations or vice versa, were implicitly identified to be both human intentional (corrupted) and unintentional (erroneous) actions .Analysis of field observations, interview and questionnaire data particularly, tables 4.4,4.5,4.6,4.7 ,4.8,4.9,4.10 and 4.11 indicated the root causes, their category and importance level. Those human actions as root causes of FEECI on the other hand, were manifested by indicators proposed and listed in question 8 of the questionnaire that were further categorized under technical & technological, political and cultural/behavioral practices. Although the indicators belongs to different categories, the determination of relative importance index (RII= 0.86 to 0.59) indicated that all the 20(after exclusion of ‘the irrelevant’) items or indicators were ranked from 1st – the most important to 7th – the least import indicator(s) of root cause and by themselves as root cause of FEECI in Addis Ababa as can be seen from tables 4.11.
4. The result also indicated that although there is strive for and responsible office for this, lack of integration among the infrastructural companies is one of the root causes of FEECI in Addis Ababa. However, it is not the only root cause and solution, though many respondents and member of the established committee of the ‘Integrated National Infrastructures’ speak of it repeatedly; Furthermore, the result indicates the need of rethink those root causes identified belonging to human actions without leaving the integration issue aside.
5. The empirical equation intended for estimation mechanism of impacts of FEECI was modified or redeveloped from the notions of existing mechanisms, to be ‘ $I_t = I_e + \sum (I_i * f_i)$ ’ considering frequency of the excavations or infrastructural rework. The multiple regression model shown in equation 4.3 also developed as alternative and supplementary tool for impact estimation with partial validation .Moreover, simple regression model expressed in equation 4.4 and 4.5 were developed and partially validated the empirical equation as well as the multiple regression though further test is needed with respect to the other independent variables of the models.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

6. Limited resources of the country and/or the city or poverty and the nature of the topology – ups- and downs of Addis Ababa city that affect the water and sewerage systems service or causing frequent failure of the systems, were identified as another new and/or additional root causes of FEECI.

5.2 RECOMMENDATIONS

As set out earlier, main goal of this new research is investigating the main and/or root causes of frequent excavations to the existing city infrastructure (FEECI) in Addis Ababa in a way of avoiding and/or minimizing both the root causes and subsequent impacts. To avoid and/or minimize such frequent excavations and the subsequent impacts the researcher recommends that all concerning bodies shall do or (be as) the following:

1. Every individual & community (all infrastructural stakeholders) shall have understanding on root causes & subsequent impacts of frequent excavations to existing city infrastructure of Addis Ababa as well shall have attitudinal & cultural change on how to use & handle public infrastructure with sense of ownership.
2. For all community, particularly that of Addis Ababa, there shall be good culture of disposing solid wastes & keeping streets & city clean, beautiful and attractive.
3. Theft, vandalism and terrorism damage of existing infrastructure shall be banned by attitudinal change and/or legal enactments.
4. Universities shall give emphasis to develop independent curriculum to give deep infrastructural related trainings & educations in order to produce competent professionals in attitude, technical (knowledge & skill) than currently available.
5. There shall be robust & applicable guidelines, rules, regulations & statutory implementation regarding infrastructure particularly, city infrastructure from initiation through operation to demolition stages.
6. There shall be appropriate feasibility study (planning & design) for construction of new, upgrading, maintenance and repairing of existing city infrastructure.
7. There shall be good workmanship during excavation & reinstatement of existing road & walkway.
8. There shall be good supervision by committed & experienced/skilled professionals during infrastructural works

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

9. Appropriate quality & quantity of materials with required characteristics shall be used appropriately during construction of new, maintenance & repairing of existing city infrastructure.
10. There should be strict and advanced integration than the started one, among infrastructural companies particularly, (AACAUBGDB, AACRA, AAWSA, EEU, ETC) and others both internally & externally.
11. Utility companies shall use new technologies including but not limited to: MUT—Multi-utility tunnel, TT—Trench -less technology, GPR-Ground Penetrating Radar etc. to avoid and/or minimize the frequent excavations and subsequent impacts when and where ever feasible after further research on its cost.
12. There shall not be unnecessary interference, influence and abuse of power by government higher officials for political leverage than the technical requirement of infrastructural issues.
13. There shall not be ‘pork barreling’—loosely meaning , political use of government budget earmarked or allocated for infrastructural work by officials to their political interest there by affecting the quality ,quantity & schedule of public facilities.
14. All concerning bodies shall use the identified & ranked indicators of human actions as root causes of FEECI as per their relative importance index(RII) found by this research when & where ever working on infrastructural issues(see table 4.10 and 4.11)
15. There shall be legal enactments and/or enforcement against infrastructural damage & corrupted practices.
16. Concerned stakeholders shall use these modified and/or redeveloped models & guidelines.

5.3 Proposal for future research not filled gap

The impact of frequent excavations to existing city infrastructure (FEECI) of Addis Ababa particularly, those related to societal (health & safety and/or convenience) & environmental were studied mainly in qualitative method and not fully quantified or estimated in terms of money yet. To do so, the developed empirical equation & multiple regression models have to be fully validated when all necessary data have to be available. Thus, future research shall fill this gap to enhance appropriate decisions regarding infrastructural related issues.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

REFERENCES

- Addis Ababa Geographic coordinates –Latitude & longitude,
<https://www.geodatos.net/en/coordinates/ethiopia/addis-ababa>. (Accessed on 21/12/2023)
- Addis Ababa's 10th Master Plan Sees 13 Districts: <https://addisfortune.net/articles/addis-abebas-10th-master-plan-sees-13-districts/> (accessed on 5/20/2024)
- Al-Bayati, A.J. and Panzer, L., 2020. Reducing damages to underground utilities: Importance of stakeholders' behaviors. *Journal of construction engineering and management*, 146(9), p.04020107.
- Alegre, H. and Coelho, S.T., 2012. Infrastructure asset management of urban water systems. Water supply system analysis–Selected topics, pp.49-74.
- Alehashemi, A., Mansouri, S.A. and Barati, N., 2017. Urban infrastructures and the necessity of changing their definition and planning Landscape infrastructure; A new concept for urban infrastructures in 21st century. *Journal of Bagh-E Nazar*, 13(43), pp.5-18.
- Allerhand, A., 2020. Hydroelectric Power: The First 30 Years [History]. *IEEE Power and Energy Magazine*, 18(5), pp.76-87.
- Al-Turki, U.M., Ayar, T., Yilbas, B.S. and Sahin, A.Z., 2014. Integrated maintenance planning. In *Integrated Maintenance Planning in Manufacturing Systems* (pp. 25-57). Springer, Cham.
- Appleton, J.V., 1995. Analysing qualitative interview data: addressing issues of validity and reliability. *Journal of advanced nursing*, 22(5), pp.993-997.
- Arisz, H. and Burrell, B.C., 2006, May. Urban drainage infrastructure planning and design considering climate change. In *2006 IEEE EIC Climate Change Conference* (pp. 1-9). IEEE
- Aschauer, D.A., 1990. Why is infrastructure. *Industry Week*, pp.21-50.
- Ashley, R. and Cashman, A., 2006. The impacts of change on the long-term future demand for water sector infrastructure. *Infrastructure to, 2030*, pp.241-349.
- Assefa, A., 2008. Time Cost Relationships for Public Road Construction Projects in Ethiopia,' the school of graduate studies faculty of technology department of civil engineering.
- Baldwin, J.R. and Dixon, J., 2008. Infrastructure Capital: What is it? Where is it? How Much of it is There?
- Bekele, F., 2018. Problems and Challenges on Addis Ababa Land and Infrastructure

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Management: Towards an Information System Strategy.

Benedict, M.A. and McMahon, E.T., 2002. Green infrastructure: smart conservation for the 21st century. *Renewable resources journal*, 20(3), pp.12-17.

Bernold, L.E., 2003. Economic model to optimize underground utility protection. *Journal of construction engineering and management*, 129(6), pp.645-652.

Bonnal, P., Gourc, D. and Lacoste, G., 2002. The life cycle of technical projects. *Project Management Journal*, 33(1), pp.12-19.

Brown, L.J. and Dixon, D., 2014. *Urban design for an urban century: Shaping more livable, equitable, and resilient cities*. John Wiley & Sons

Capdevila-Werning, R. and Lehtinen, S., 2021. Intergenerational aesthetics: A future-oriented Approach to aesthetic theory and practice. *Philosophical Inquiries*, 9(2), pp.171-194

Cities and infrastructure day (<https://youtu.be/LhwtykfQjVA?si=LJMIX-GDdfCz-SHv>)

Clearinghouse for Military Family Readiness (<https://militaryfamilies.psu.edu>)

Creswell, J.W., Fetters, M.D. and Ivankova, N.V., 2004. Designing a mixed methods study in primary care. *The Annals of Family Medicine*, 2(1), pp.7-12.

Czernich, N., Falck, O., Kretschmer, T. and Woessmann, L., 2011. Broadband infrastructure and economic growth. *The Economic Journal*, 121(552), pp.505-532.

Daniela, L., 2011. Decision-support tools for municipal infrastructure maintenance management. *Procedia Computer Science*, 3, pp.36-41.

Dinsa, Y., 2015. Assessment of the causes and effects of price escalation of federal road contracts in ethiopia (Doctoral dissertation, Addis Ababa University).

Dyer, M., Dyer, R., Weng, M.H., Wu, S., Grey, T., Gleeson, R. and Ferrari, T.G., 2019. Framework for soft and hard city infrastructures. *Proceedings of the Institution of Civil Engineers-Urban Design and Planning*, 172(6), pp.219-227.

Echendu, A.J., Guinot, J., Xu, C., Russo, F., Calabrò, T., Iiritano, G., Pellicanò, D.S., Petrunaro, G., Trecozzi, M.R., Suprayogi, S. and Mutaqin, B.W., 2020. Urban Planning—“It’s All About Sustainability”: Urban Planners’ Conceptualizations of Sustainable Development in Port Harcourt, Nigeria. *development*, 3, p.4.

Echendu, A.J. and Okafor, P.C.C., 2021. Smart city technology: a potential solution to Africa's growing population and rapid urbanization?. *Development Studies Research*, 8(1),

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

pp.82-93.

- Esper, P. and Tachibana, E., 1998. Lessons from the Kobe earthquake. Geological Society London, Engineering Geology Special Publications, 15(1), pp.105-116.y,
- Foster, V. and Morella, E., 2010. *Ethiopia's infrastructure: a continental perspective*. World Bank.
- Future of Addis Ababa 2021: Addis Ababa's Strategic Development Framework (English). Washington, D.C.: World Bank Group
<http://documents.worldbank.org/curated/en/841961623399992742/Future-of-Addis-Ababa-2021-Addis-Ababa-s-Strategic-Development-Framework>
- Gebreegziabher, M., 2014. Causes and Effects of Poor Inter Sectoral Linkage in Infrastructure Development Works: The Case of Road and Light Rail Construction Projects in Addis Ababa, MA Thesis in Urban Development and Management, Addis Ababa University, Ethiopia.
- Ghiday, A. B., 2022. Assessment of the Integration of Condominium Housing Projects with the Other Infrastructure Supplying Institutions: The Case of 40/60 Housing Provision, A Thesis Submitted to College of Urban Development and Engineering, Ethiopian Civil Service University, in Partial Fulfillment of the Requirements for the Award of a Master's Science Degree in Urban Planning and Development (unpublished).
- Gibson Jr, G.E., Wang, Y.R., Cho, C.S. and Pappas, M.P., 2006. What is preproject planning, anyway?. *Journal of management in engineering*, 22(1), pp.35-42.
- Greene, L. and Burke, G., 2007. Beyond self-actualization. *Journal of health and human services administration*, pp.116-128.
- Greiving, S., Fleischhauer, M., León, C.D., Schödl, L., Wachinger, G., Quintana Miralles, I.K. and Prado Larraín, B., 2021. Participatory assessment of multi risks in urregions—The case of critical infrastructures in metropolitan lima. *Sustainability*, 13(5), p.2813.
- Guidelines for Excavation Work Done Near Our Underground Infrastructures” — ‘Info-Excavation’ available on <https://www.info-ex.com/>
- Guideline for Excavation in the Vicinity of Utility Lines (<https://www.digsafe.ca/wp-content>)
- Guo, H., Li, H. and Skitmore, M., 2010. Life-cycle management of construction projects based on virtual prototyping technology. *Journal of Management in Engineering-ASCE*, 26(1), pp.41-47.
- Herslund, L., Backhaus, A., Fryd, O., Jørgensen, G., Jensen, M.B., Limbumba, T.M., Liu, L., Mguni, P., Mkupasi, M., Workalemahu, L. and Yeshitela, K., 2018. Conditions and opportunities for green infrastructure—Aiming for green, water-resilient cities in Addis

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

- Ababa and Dar es Salaam. Landscape and urban planning, 180, pp.319-327.
- Heymann, D.L. and Dar, O.A., 2014. Prevention is better than cure for emerging infectious diseases. *Bmj*, 348.
- Hojjati, A., Jefferson, I., Metje, N. and Rogers, C.D.F., 2016. Sustainable asset management for utility street works. In *Transforming the Future of Infrastructure through Smarter Information: Proceedings of the International Conference on Smart Infrastructure and Construction*, 27–29 June 2016 (pp. 669-674). ICE Publishing.
- Hovde, P.J. and Moser, K., 2004. Performance based methods for service life prediction. State of the art reports, CIB Report: Publication, 294.
- How to Report Cronbach's Alpha (With Examples)
(<https://www.statology.org/how-to-report-cronbachs-alpha/>)
- Hulten, C.R., 1996. Infrastructure capital and economic growth: How well you use it may be more important than how much you have.
- Mattew.F, Humphreys., 2003. Extending the service life of buildings and infrastructure with fibre composites.
- Hunt D.V.L., Makana, L.O., Jefferson, I. and Rogers, C.D.F., 2016. Livable cities and urban underground space. *Tunnelling and Underground Space Technology*, 55, pp.8-20.
- Hunt, D.V.L., Nash, D. and Rogers, C.D.F., 2014. Sustainable utility placement via multi-utility tunnels. *Tunnelling and Underground Space Technology*, 39, pp.15-26.
- Infrastructure day: Fana Tv
(<https://youtu.be/LhwykfQjVA?si=LJMIX-GDdfCz-SHv>) Accessed on September 20/2023
- Infrastructure: Definition, Meaning, and Examples
(<https://www.investopedia.com/terms/i/infrastructure.asp>) (accessed on 06, June, 2022).
- Infrastructure Vandalism and Protection in a Vulnerable Zimbabwean Environment: Review of the Structural. Materialism Theory
(www.ijrte.org/wpcontent/uploads/papers/v10i3/C63550910321.pdf) (accessed on October 12/2023)
- Jim, C.Y., 2003. Protection of urban trees from trenching damage in compact city environments. *Cities*, 20(2), pp.87-94.
- Johari, S. and Jha, K., 2019. Determinants of workmanship: defining quality in construction industry. In *Proceedings of the 35th Annual Conference; Leeds Beckett University: Leeds, UK* (p. 761).

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

- Jung, Y.J. and Sinha, S.K., 2007. Evaluation of trenchless technology methods for municipal infrastructure system. *Journal of infrastructure systems*, 13(2), pp.144-156.
- Kasper, E., 2015. A Definition for Infrastructure-Characteristics and Their Impact on Firms Active in Infrastructure (Doctoral dissertation, Technische Universität München).
- Khogali, W.E. and Mohamed, E.H., 1999. Managing utility cuts: issues and considerations. In *APWA International Public Works Congress NRCC/CPWA Seminar Series "Innovations in Urban Infrastructure"* (pp. 1-11).
- Kimengsi, J.N. and Fogwe, Z.N., 2017. Urban green development planning opportunities and challenges in sub-saharan Africa: Lessons from Bamenda city, Cameroon. *International Journal of Global Sustainability*, 1(1), pp.1-17.
- Kumar, A. and Meshram, D.S. (eds.) 2022. *Future of Cities: Planning, Infrastructure, and Development*. New York, NY 10158: Routledge.
- Lay, M.G., 2013. Public infrastructure: An historical perspective. *Road & Transport Research: A Journal of Australian and New Zealand Research and Practice*, 22(2), pp.62-68.
- Leong, W.W., 2005. The impact of trenching on urban road operation and maintenance.
- Lerner, A.C., 1996. Infrastructure obsolescence and design service life. *Journal of infrastructure systems*, p.153.
- Love, P.E., Ackermann, F., Smith, J., Irani, Z. and Edwards, D.J., Making Sense of Rework: Reflections from the Blunt and Sharp End in Projects.
- Love, P.E., Lopez, R. and Edwards, D.J., 2013. Reviewing the past to learn in the future: Making sense of design errors and failures in construction. *Structure and Infrastructure Engineering*, 9(7), pp.675-688.
- Love, P.E., Smith, J., Ackermann, F. and Irani, Z., 2019. Making sense of rework and its unintended consequence in projects: The emergence of uncomfortable knowledge. *International journal of project management*, 37(3), pp.501-516.
- Luo, X. and Xu, X., 2018. Infrastructure, value chains, and economic upgrades. *World Bank Policy Research Working Paper*, (8547).
- Lubbers, C., 2013. Asset control: improving wastewater transport system performance. *Water Asset Management International*, 9(2), pp.3-6.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

- Luo, Y., Alaghbandrad, A., Genger, T.K. and Hammad, A., 2020. History and recent 103, development of multi-purpose utility tunnels. *Tunnelling and Underground Space Technology*, p.103511.
- Luo, Y., Zhang, C. and Hammad, A. (2019) Recent Development of Multi-Purpose Utility Tunnels in China.
- Makana, L, Metje, N, Jefferson, I, Sackey, M & Rogers, C 2019, 'Cost estimation of utility strikes: towards proactive management of street works', *Infrastructure Asset Management*, vol. 7, no. 2, pp. 64-76.
- Mangizvo, R.V., 2010. Illegal dumping of solid waste in the alleys in the central business district of Gweru, Zimbabwe. *Journal of Sustainable Development in Africa*, 12(2), pp.110-123.
- Marcotullio, P.J. and Solecki, W., 2013. What is a city? An essential definition for sustainability. In *Urbanization and Sustainability* (pp. 11-25). Springer, Dordrecht.
- Maslow, A.H., 1971. *The farther reaches of human nature* (Vol. 19711). New York: Viking press.
- Maunier, R., 1910. The definition of the city. *American journal of sociology*, 15(4), pp.536-548
- McCluskey, E.G., Thompson, S. and McSherry, D.M.G., 1988. Standards, codes of practice and expert systems. *Measurement and Control*, 21(1), pp.5-9.
- McCombes, S. (2023, May 31). *What Is a Research Design | Types, Guide & Examples*. Scribbr. Retrieved August 2, 2023, from <https://www.scribbr.com/methodology/research-design/>
- Mengistu, A. and ABABA, A., 2017. Assessment of Source of Funds, Power System Efficiency, Electricity Tariff and Financial Performance: Case of Ethiopian Electric Power and Ethiopian Electric Utility (Doctoral dissertation, Addis Ababa University).
- Metje, N., Ahmad, B. and Crossland, S.M., 2015, September. Causes, impacts and costs of strikes on buried utility assets. In *Proceedings of the institution of civil engineers-municipal engineer* (Vol. 168, No. 3, pp. 165-174). Thomas Telford Ltd.
- Metje, N., Atkins, P.R., Brennan, M.J., Chapman, D.N., Lim, H.M., Machell, J., Muggleton, J.M., Pennock, S., Ratcliffe, J., Redfern, M. and Rogers, C.D.F., 2007. Mapping the underworld—state-of-the-art review. *Tunnelling and underground space technology*, 22(5-6), pp.568-586.
- Minalu, Y., 2014. Performance Evaluation of Addis Ababa City Road Network (Doctoral dissertation, Addis Ababa University).

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

- Moran, J., Eskandari Torbaghan, M. and Burrow, M.P., 2017. Estimating the benefits of joint occupation for street works in the UK. *Infrastructure Asset Management*, 4(4), pp.115-127.
- Morgan G, Ceppi P, Crosskey S, & O'Regan N. 2019. *The Importance of Infrastructure for Landlocked Developing Countries*. UNOPS, Copenhagen, Denmark.
- Moteff, J. and Parfomak, P., 2004, October. Critical infrastructure and key assets: definition and identification. Library of Congress Washington DC Congressional Research Service.
- Muggleton, J.M., Brennan, M.J. and Rogers, C.D.F., 2014. Point vibration measurements for the detection of shallow-buried objects. *Tunnelling and Underground Space Technology*, 39, pp.27-33.
- Muguruma, H., Nishiyama, M. and Watanabe, F., 1995. Lessons learned from the Kobe earthquake—A Japanese perspective. *Pci Journal*, 40(4), pp.28-42.
- Murray, S., 2019. The critical role of infrastructure for the Sustainable Development Goals. The Economist Intelligence Unit.
- Naoum, S.G., 2012. *Dissertation research and writing for construction students*. Routledge.
- Networking Information, News and Tips from Tech Target
(<https://www.techtarget.com/searchnetworking/>) accessed on 14/10/2023
- Neuman, M. and Smith, S., 2010. City planning and infrastructure: once and future partners. *Journal of Planning History*, 9(1), pp.21-42.
- Nijkamp, P. and Ubbels, B., 1999. Infrastructure, suprastructure and ecostructure: a portfolio of sustainable growth potentials. *Research Memorandum*, 51.
- Occupational Safety and Health Administration (OSHA 2226-10R 2015) Trenching and Excavation Safety, U.S. Department of Labor.
- Ouyang, M., 2014. Review on modeling and simulation of interdependent critical infrastructure systems. *Reliability engineering & System safety*, 121, pp.43-60.
- Parkin, J. and Sharma, D., 1999. *Infrastructure planning*. Thomas Telford.
- Pilvar, R., 2015. Development of an optimization model for scheduling of street works schemes (Doctoral dissertation, University of Leeds).
- Polyzos, S. and Tsiotas, D. 2020. The Contribution of Transport Infrastructures to the Economic

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

and Regional Development: A review of the Conceptual Framework: *Theoretical and Empirical Researches in Urban Management*, 15 (1), 5-23.

Portillo, A. and Moya, L., 2023. Seismic Risk Regularization for Urban Changes Due to Earthquakes: A Case of Study of the 2023 Turkey Earthquake Sequence. *Remote Sensing*, 15(11), p.2754.

Pre-startup Safety Review Training: Hurricane Project
(<https://tools.niehs.nih.gov/wetp/public/Course...>)

Qureshi, Z., 2016. Meeting the challenge of sustainable infrastructure: The role of public policy

Rahman, H.A., Beznosov, K. and Marti, J.R., 2009. Identification of sources of failures and their propagation in critical infrastructures from 12 years of public failure reports. *International Journal of Critical Infrastructures*, 5(3), pp.220-244.

Rankin, W.J., 2009. Infrastructure and the international governance of economic development, 1950–1965. In *Internationalization of Infrastructures: Proceedings of the 12th Annual International Conference on the Economics of Infrastructures* (pp. 61-75). Delft: Delft University of Technology.

Reducing damage to underground utility infrastructure.
(<https://gita.memberclicks.net/assets/Final White...>)

Roads, N. and Act, S.W., 1991. Specification for the Reinstatement of Openings in Highways. *Department of transport, Code of Practice for England*.

Rogers, C.D.F. and Hunt, D.V.L., 2006, May. Sustainable utility infrastructure via multi-utility tunnels. In *Proceedings of the Canadian Society of Civil Engineering 2006 conference, Towards a sustainable future*, Calgary.

Rooshdi, R.R.R.M., Abd Majid, M.Z., Sahamir, S.R. and Ismail, N.A.A., 2018. Relative Importance index of sustainable design and construction activities criteria for green highway. *Chemical engineering transactions*, 63, pp.151-156.

Santos, E.A.N.e.; Dutra, C.T.d.S.; Chinelli, C.K.; Hammad, A.W.A.; Haddad, A.N.; Soares, C.A.P., (2021) The Main Impacts of Infrastructure Works on Public Roads. *Infrastructures* 2021, 6, 118. <https://doi.org/10.3390/infrastructures6090118>

Seifu, S. and Stellmacher, T., 2021. Accessibility of public recreational parks in Addis Ababa, Ethiopia: A GIS based analysis at sub-city level. *Urban Forestry & Urban Greening*, 57, p.126916.

Shan, C. and Yai, T., 2011. Public involvement requirements for infrastructure planning in

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

- China. Habitat international, 35(1), pp.158-166.
- Shanko, M., 2002. Overview of the Electricity Sector in Relation to Public Private Partnerships in Ethiopia.
- Shen, L.Y., Tam, V.W., Tam, L. and Ji, Y.B., 2010. Project feasibility study: the key to successful implementation of sustainable and socially responsible construction management practice. *Journal of cleaner production*, 18(3), pp.254-259.
- Sierra, K., 2011. Sustainable infrastructure for urban growth. World, 2050.
- Sietchiping, R., Permezel, M.J. and Ngomsi, C., 2012. Transport and mobility in sub-Saharan African cities: An overview of practices, lessons and options for improvements. *Cities*, 29(3), pp.183-189.
- Simpeh, E.K., 2012. *An analysis of the causes and impact of rework in construction projects* (Doctoral dissertation, Cape Peninsula University of Technology).
- Song, Y., 2012. Infrastructure and urban development: Evidence from Chinese cities. In Proc. 2012 L. Policy Conf (pp. 21-60).
- Suhrcke, M., McKee, M., Stuckler, D., Arce, R.S., Tsoлова, S. and Mortensen, J., 2006. The contribution of health to the economy in the European Union. *Public health*, 120(11), pp.994-1001
- Swilling, M., 2006. Sustainability and infrastructure planning in South Africa: a Cape Town case study. *Environment and Urbanization*, 18(1), pp.23-50.
- Taherdoost, H., 2016. Sampling methods in research methodology; how to choose a sampling technique for research. *How to choose a sampling technique for research (April 10, 2016)*.
- The Basics of Infrastructure Excavation - Pinoy Builders
(<https://www.pinoybuilders.ph/basics-of-infrastructure-excavation-2/>) (accessed on 12/9/2022).
- Tribot, A.S., Deter, J. and Mouquet, N., 2018. Integrating the aesthetic value of landscapes and biological diversity. *Proceedings of the Royal Society B: Biological Sciences*, 285(1886), p.20180971.
- Types of Excavation Used in Construction (13 Common ...
(<https://ronmeyerexcavating.com/types-of-excavation/>) (Accessed on 12/9/2022)
- Understanding the Risks Involved When Having Surgery: No surgery is risk-free but what are – the risks? (see <https://www.verywellhealth.com>) accessed on 10 September, 2022

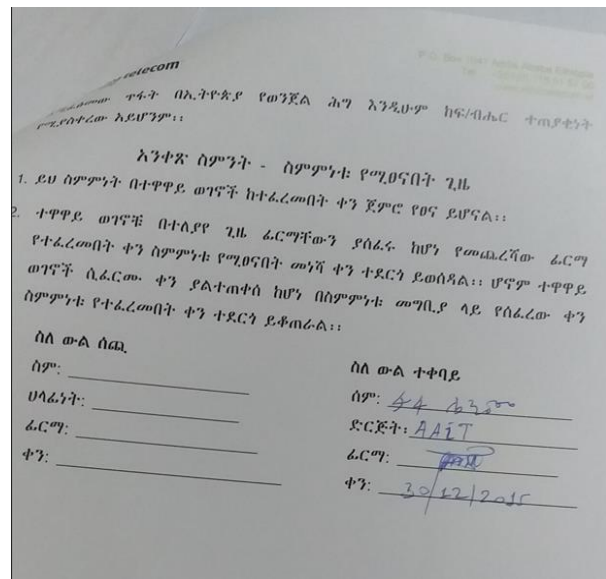
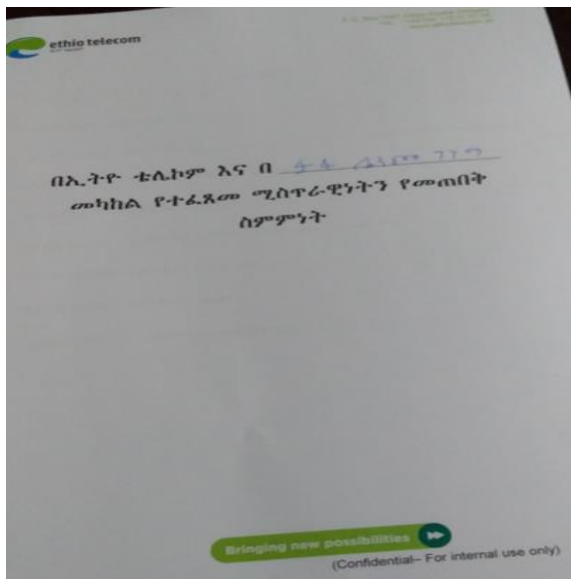
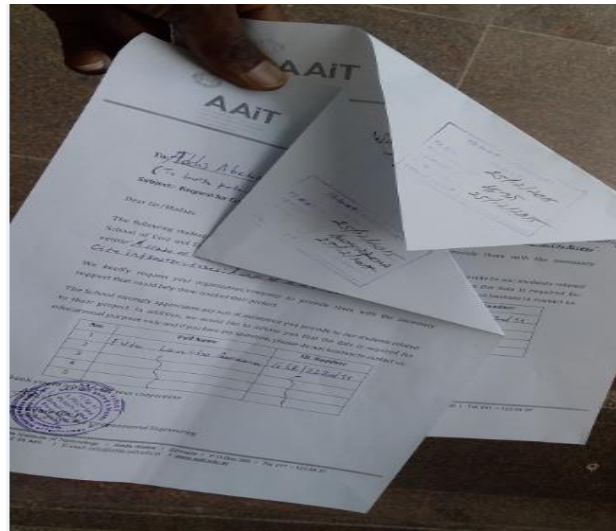
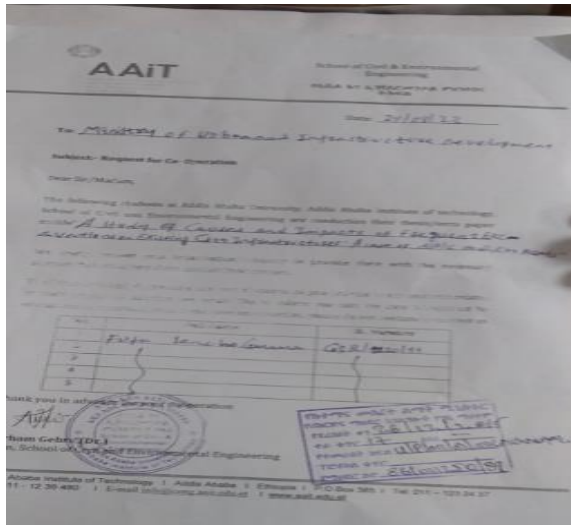
Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

- Unterberger, Ch., 2017. How Flood Damages to Public Infrastructure Affect Municipal Budget Indicators
- Van der Heijden, R.E., 1996. Planning large infrastructure projects: seeking a new balance between engineering and societal support. *disP-The Planning Review*, 32(125), pp.18-25.
- Verywell Health - Know More. Feel Better. (<https://www.verywellhealth.com>)
- Wallace, W.A., Mendonca, D., Lee, E.E., Mitchell, J.E. and Chow, J., 2003. Managing Center disruptions to critical interdependent infrastructures in the context of the 2001 World Trade attack. Beyond September 11th: An account of post-disaster research, pp.165-198.
- Waverman, L., Meschi, M. and Fuss, M., 2005. The impact of telecoms on economic growth in developing countries. The Vodafone policy paper series, 2(03), pp.10-24.
- What are Pork Barrel Politics? (<https://www.investopedia.com/ask/answers/042115/what-are-some-examples-pork-barrel-politics-united-states.asp>-- accessed on 14/8/2024)
- What Is an Economy? (<https://www.investopedia.com/terms/e/economy.asp#toc-what-is-an-economy>) accessed on 27/04/2024)
- What is hardscape? (<https://www.reliance-foundary.com/blog/category/hardscape>) accessed on June 06/2022)
- What is infrastructure? (See <https://www.investopedia.com/terms/i/infrastructure.asp>) (Accessed on 06, June, 2022)
- Weldeghebrael, E.H., 2021. Addis Ababa: City scoping Study. *The African Cities Research consortium*. University of Manchester.
- World Economic Situation and Prospects, 2012. Country Classification, Data Sources, Country Classifications and Aggregation Methodology.
- Yashiro, K., Kojima, Y. and Shimizu, M., 2007. Historical earthquake damage to tunnels in Japan and case studies of railway tunnels in the 2004 Niigataken-Chuetsu earthquake. *Quarterly Report of RTRI*, 48(3), pp.136-141.
- Zegeye, Y., 2012. The problem of urban infrastructure provision in Ethiopia: The case of Bahirdar city, MSc Thesis in Urban Design and Development. EiABC.
- Zohar, M., Salamon, A. and Rubin, R., 2017. Earthquake damage history in Israel and its close surrounding-evaluation of spatial and temporal patterns. *Tectonophysics*, 696, pp.1-13.

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

APPENDICES

Appendix A: Letters of cooperation request by Addis Ababa University Institute of Technology and the researcher (Fufa Lencho) for respondents and contract signed between Ethio-telecom for the confidentiality of information



Appendix B: Data collecting Tools:

Appendix B1: Field Observation checklist

**Addis Ababa University
School of Graduate Studies
Addis Ababa Institute of Technology
School of Civil and Environmental Engineering
Masters Program in Construction Technology and Management**

Field/site observation data collection checklist

This checklist was used by the author—Fufa Lencho, to collect or record data during field observation in the process of investigating the causes and impacts of excavation and/or frequent infrastructural street works to the existing infrastructure of Addis Ababa City. The data were used supplementing data from other sources in which all used for partial fulfillment of the requirement of master degree in Construction technology and Management conducting the research titled ‘*A study of causes and impacts of frequent excavations on existing city infrastructures: A case of Addis Ababa City Streets and Utility Assets*’.

I. General data/ information

1. Location of the excavation activity within the city, Addis Ababa :
 - ❖ Sub-city: _____; Woreda _____; Unique name _____
2. Type of the excavation:
 - ❖ In to sub surface or ground:
 - Open cut excavation /Mass excavation
 - Trench excavation
 - Pit excavation
 - ❖ To asphalt and/or coble stone paved surfaces of roadways/ walkways greenery:
 - Surface course/pavement removal
 - Cutting in to asphalt roadway surface course
 - Removing pavement block/units of coble stone roads/sidewalks
 - Removal/damage of greenery (grass and tree roots)
3. Responsible/accountable Executer of the excavation activity:
 - ❖ Governmental legal person(s)—optional :
 - Client _____
 - Contractor/subcontractor _____
 - Consultant and/or regulatory body _____
 - ❖ None Governmental/private legal or illegal person(s)—optional :
 - Household inhabitants of the vicinity
 - Community of the vicinity

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

- Unknown individual(group of individuals)
- 4. Frequency/number of repetition of excavation activity at the vicinity:
 - ❖ At/under the same surface/area/location, in different periods of time
 - Once only until now
 - Twice
 - Three times
 - More than three times
 - ❖ Within the same period of time (weeks, months) but at/in different (more than two) locations and/or surfaces, areas, sub-cities, “woredas”

II. Detail data: causes and impacts of the excavation(s)

5. Immediate cause or purpose of the excavation (thick the appropriate cause):

- ❖ Construction/installation of new infrastructure:
- ❖ Routine maintenance of the existing infrastructure asset:
- ❖ Preventive/proactive /routine maintenance of the existing infrastructure asset:
- ❖ Expansion/upgrading of the existing infrastructure:
- ❖ Replacement/repairing of damaged existing infrastructure(road/street and related):
 - Roadway
 - Walkway
 - Curb stone
 - Storm water system
 - Manhole
 - Median
- ❖ Replacement/repairing of damaged existing infrastructure(utilities):
 - Potable water pipe
 - Sewerage/ waste water system
 - Electric power: buried cable/wire pole/post
 - Telecommunication:
 - Landline telephone cable
 - Fiber optics cable
 - CCTV /security camera cables
 - Post/pole of overhang cables/wires
 - Pipes and/or manholes
 - Others

6. Root cause of the excavation :

- ❖ Human intentional/unintentional actions through technical, political and cultural practices:
 - Poor quality of material, work man ship hence early and frequent failure of facility
 - Misuse and poor management of the infrastructure
 - Vandalism and theft damaged infrastructural assets
 - Error calculation ,estimation and specification lead to obsolescence or damage

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

9. Impact of the infrastructure works/excavations

- ❖ **Safety and/or inconvenience**
 - A potential for Injury/death (treatment expenses plus loss of productivity)
 - Inconvenience : difficulty of movement particularly to disabled, elders and children
 - Inconvenience to motorists
- ❖ **Aesthetics**
 - Dusty and/ or muddy streets/environment affecting health , quality of life and increasing cleaning and beautification cost
 - Rough , disturbed and damaged vicinity
- ❖ **Economic/sustainability**
 - Direct cost of construction (material, labor, tools, equipment)
 - Loss of productivity and/or income due to service interruption/ ineffective performance
 - The potential of over consuming resource –affecting sustainability

III. Additional Notes:

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Appendix B2: Interview Question to infrastructural companies

Addis Ababa University
School of Graduate Studies

Addis Ababa Institute of Technology
School of Civil and Environmental Engineering
Masters Program in Construction Technology and Management

Interview questions with Infrastructural companies: (AACAU, AACRA, AAWSA, EEU and ETC)

Dear Sir/Madam,

I am (the author) undertaking academic research under the title '*A study of causes and impacts of frequent excavations on existing city infrastructures: A case of Addis Ababa City Streets and Utility Assets*' for partial fulfillment of the requirements of Masters of Science in Construction Technology and Management. The general objective of the study is to investigate the causes and impacts of frequent and arbitrary excavations on the existing infrastructure of Addis Ababa City.

The existing infrastructure of the city particularly, the street with all its components, utilities and roadside greeneries are vital for daily life of dwellers and visitors of the city and Economic growth and development of the nation.

Because your company is one of the main stake holders, the researcher believe that your participation in this study is very important. Thus, making this interview with you is intended to collect reliable data for the purpose of accomplishment of academic research and at the same time to solve the stated real problem of the city infrastructure (streets with all its components road side greenery and utilities) that is damage due to frequent and arbitrary excavations. Therefore, I kindly request your consent for participation/response to the questions.

The questions present here are common to all sectors but will be supplemented by additional and specific questions to each corresponding company during the interview as it is semi structured type. The interview will be recorded for the later transcription of the content whose confidentiality will be kept by limiting its access only to the researcher (Fufa Lencho) and to the advisor (Dr. Robam Solomon). After completing and publication of the study I promise you that whenever you requested you can access the copy of the work either through Addis Ababa University or through me.

I would like to say **thank you in advance** for your willingness to participate in the interview!

With best regards

Fufa Lencho

A candidate of Master degree in Construction Technology and Management at Addis Ababa University, Faculty of Technology, Civil Engineering Department.

Contact address: +251- 917027472 or obsifufa@gmail.com

Addis Ababa

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

I. Introductory and impact investigation questions

1. Have you ever noticed arbitrary and frequent excavations and damages to the existing infrastructure (utility assets, walkways and roadways) within our city, Addis Ababa?

1. I have noticed many times 2. I never noticed

2. Do you agree that arbitrary and frequent excavations or infrastructural reworks within the city have *health & safety/inconvenience, aesthetic* and *economic* influences on individuals, community, city and sustainable development at all? 1. I agree 2. I disagree

2.1 Would you *elaborate impacts* of such *frequent excavations* or *reworks* to the existing infrastructure of the city and users in terms of: (a) Health & safety/inconvenience, (b) aesthetic and (c) economy/sustainability?

2.2. Can you substantiate the annual repairing costs incurred by your company beyond planned or expected within the same period of time? Please provide documents showing this?

3. From your observation, which of the available and/or known *infrastructural companies* more frequently undertake infrastructural reworks? Please rank them in the space provided below:

1. _____	2. _____
3. _____	4. _____
5. _____	6. _____
7. _____	8. _____

II. Root Causes investigation inquiries

4. Why do you think these companies or other agencies frequently undertake frequent excavations/reworks to the existing city infrastructure? Please elaborate the reason/root causes of such frequent reworks:

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

4.1. What is your perception regarding the *quality, standard* and *capacity* of existing city infrastructures of Addis Ababa? Please explain

5. Do you agree that *poor quality* and *non-met requirements* result in to *early* and *frequent failure* (damage/collapse and/or obsolescence) of infrastructure? 1. I Agree 2. I Disagree

6. Do you think that such defects are due to intentional and/or unintentional human actions either *corruption* or error committed by people (infrastructural stake holders), during *technical* (planning, designing, construction, operation & maintenance) *practices* & **political** decision making of infrastructural works? Please explain

6.1. Please express *the process* of infrastructural/utility works and service provision within your company

7. What is the tangible condition of your company regarding equipment and proper implementation of reliable *guidelines, standards, procedures* for infrastructural works? Explain

7.1 Are there *alternative solutions* or *technologies* such as trenchless technology —TT & Multi-utility tunnel—MUT and others for utility installation for infrastructures? Explain

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

8. How do you explain the *communication, coordination, cooperation* status within each infrastructural company and between each other? Can it be one of the root causes? Explain

9. What is your observation regarding the *culture or behavior* of individuals and community towards infrastructure usage and/or handling with ownership feeling? Explain

III. Suggestion as guidelines for effective infrastructural works and services

10. What is/are your suggestion(s) to avoid/minimize the unnecessary frequent and arbitrary reworking /excavations to the existing city infrastructures of our city, Addis Ababa? Please forward what you think in terms of the following:

10.1 What should be done?

10.2 Who have to do?

10.3 When and how to do?

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Appendix B3: Questionnaire survey

Questionnaire for Professional Personnel in Infrastructure Sectors of Ministry of Urban and Infrastructure (MUI) & Addis Ababa Construction Permit and Control Authority (AACPCA)

**Addis Ababa University
School of Graduate Studies
Addis Ababa Institute of Technology
School of Civil and Environmental Engineering
Master's Program in Construction Technology and Management**

Dear Sir/Madam,

This questionnaire is intended to collect data for academic research being undertaken under the title '*A study of causes and impacts of frequent excavations on existing city infrastructures: A case of Addis Ababa City Streets and Utility Assets*' for partial fulfillment of requirements for Masters of Science in Construction Technology and Management.

The general objective of the study is to investigate the *root causes* and impacts of frequent and arbitrary excavations on the existing infrastructure of Addis Ababa City. The questionnaire covered investigating impacts of frequent and arbitrary excavations, root cause and issues of alternative solutions and/or guidelines for city infrastructure works.

I, the researcher believed and my advisor, Dr. Robam Solomon agreed that your responses are very important not only for the academic requirement, but also for solving the practical problem of the city infrastructure related to the problem under study.

Therefore, appreciating your genuine and attentive response in advance, I kindly request you to complete/respond to the questions of this survey, following the given instructions.

With best regards

Fufa Lencho

A candidate of Masters Degree in Construction Technology and Management at Addis Ababa University, Institute of Technology, Civil and Environmental Engineering Department.

Contact address: +251- 917027472 or obsifufa@gmail.com

Addis Ababa

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

Section one: *Demographic/General Information of Respondents*

1. Educational status: B.Sc. M.Sc. PhD , Please specify if others _____
2. Your position/ title in the organization is: _____ at level:
Junior Officer Senior Officer Team Leader Director Deputy/General Manager
3. Work Experience:
< 5 years 5-10 years 10-15 years >15years

Section two: *Impacts identification and related inquiries*

1. Frequent excavations are common practice in Addis Ababa
 1. Strongly Agree
 2. Agree
 3. Neutral
 4. Disagree
 5. Strongly Disagree
2. Frequent excavations and /or street infrastructural works have impacts on:
 1. Health and safety aspects of users
 2. Aesthetics and/or beauty of the city
 3. Economic and/or sustainable development aspects of individual, community etc.
 4. All of the above
 5. Others in addition to these (list them if any):

Section three: *questions related to root causes investigation & Alternative solution Guidelines*

3. Which of the following intentional and/or unintentional human actions do you think is/are the *root cause(s)* for poorly constructed/installed, managed hence early and frequent failure of existing infrastructure in the case of Addis Ababa city?
 1. Corruption acts of technical and political stake holders
 2. Bad culture or behavior of community in infrastructure handling/usage
 3. Terrorism, conflict/war due to instable political situations
 4. Errors in engineering computations and estimations during designing
 5. Negligence and adherence to traditional infrastructure working/installation methods
 6. All of them are root causes
 7. -----and ----- only (write the number of your response)

4. Please rank in the order of their occurrence frequency if your response for the above question is “All or some” of them and list other root causes you think

- 1st _____
- 2nd _____
- 3rd _____
- 4th _____
- 5th _____

5. Which of the following do you think is/are the probable root causes of frequent failure and/or excavations of existing infrastructure occur(s)during *planning and designing stage* ?

Root Causes and Impacts of Frequent Excavations to existing City Infrastructure: A case of Addis Ababa Street and Utility Assets

1. Absence or unreliable feasibility study for infrastructural works
2. Lack of transparent and participatory infrastructure planning and decision making
3. Mismatched capacity/standard of existing infrastructure with demand/requirement due to poor forecasting/prediction
4. Erroneous/incorrect engineering computations during designing
5. Lack of design review and checking before starting any infrastructural works
6. Lack of communication and coordination of infrastructural companies
7. All of the above

6. Write “1” or “2” in the space provided to indicate that you “Agree” or “Dis agree” respectively that the following is/are **root cause** of frequent failure and/or excavations to existing infrastructure of Addis Ababa that may happen during construction/installation of new infrastructure or maintenance or repairing of the existing

1. Using inappropriate/lower quality and quantity material than the specified_____
2. Using unqualified and/or uncertified workmanship_____
3. Lack or absence of strict inspection/supervision during construction/installation_____
4. Trial excavations due to absence of information & documents on exact location of buried utilities _____
5. Absence of using technologies and/or alternative utility installation techniques_____
6. Absence/inapplicability of guidelines, standards and specifications for infrastructural works_____
7. Poor infrastructural construction/installation and maintenance techniques_____

7. Rate out of **10 marks** (writing 10, 9, 8...1 as per your experience based judgment on the provided space) the following **root causes** of frequent failure and/or excavations assumed to be happen during **operation and maintenance** of the existing infrastructure of Addis Ababa.

1. Lack of regular maintenance/pending of regular maintenance _____
2. Culture of misusing and inappropriate handling of infrastructural assets _____
3. Terrorism, war/conflict vandalism and theft actions of people to infrastructural asset_____
4. Accidental events(strike/collusion & explosion) due to carelessness or unconsciousness _____

Section Four: questions intended to measure correlations of the variables and hypothesis test

Preliminary field observation revealed that there are arbitrary and frequent excavations to the existing infrastructure of Addis Ababa city and frequent failures (damage and/or obsolescence) and vice versa imposing safety/inconvenience, aesthetic and economic impacts. Among others, *intentional* and *unintentional human actions* throughout their technical, political involvement and cultural/behavioral practices to infrastructural works are anticipated to *be root cause(s)* of failures and frequent infrastructure *reworks* or ground disturbance. The indicators of those actions are provided as in the table in question 8.

8. Factors manifesting those human actions collected from different literatures and experience are listed by the author (me) being predicted as *root causes* of the frequent and arbitrary excavations in the following table. Please read the listed statements with full attention and then: (1) mark/tick by “✓” in the cells under columns of “*I Agree*” or “*I Disagree*” as per your observation of the phenomena and perception corresponding to each listed statement and (2) once again, **rank** as (**1st, 2nd, 3rd,..., 24th**) these listed indicators of predicted root causes of frequent excavations to existing city infrastructure of Addis Ababa in the importance order you think “*important*” in the cells corresponding to each.

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

Indicators of human actions predicted as root causes of FECCI	Do you agree this (each of the listed factors) is a root cause and/or indicator for the failure hence frequent excavations to existing city infrastructure in the case of Addis Ababa		Rank all from 1 st to the end
	Agree	Disagree	
I. Human actions during Technical (Engineering and Technological) practices			
<i>1.Planning and Designing stage</i>			
1. Spontaneous origination and sprawl development/ organically without master plan/ of Addis Ababa city			
2. Lack/absence of <i>feasibility</i> study before starting any infrastructural work			
3. Lack/absence of inclusion input data and/or comments of concerning stakeholders particularly, community			
4. Incorrect/erroneous engineering computations and specifications during designing			
5. Lack/absence of design review and checking before starting new construction and maintenance of infrastructure works			
<i>2.Construction/implementation stage</i>			
6. Lack/absence of planning & scheduling for infrastructural works			
7. Poor/inappropriate infrastructure construction/installation methods/techniques			
8. Use of inferior resources(material, man power, machinery, tools and equipment) than specified and quantified for particular infrastructural works (corruption practices)			
9. Lack/absence of alternative utility installation methods(MUT,TT) other than the traditional open cut			
10. Lack/Poor marking, mapping and documentation of exact location of buried utility lines/assets hence try and error excavations to detect any buried utility			
11. Absence/inapplicability of reliable specifications, standards, guidelines and legal frames for infrastructural and related works and Management			
12. Lack or absence of strict supervision during construction/installation and maintenance			
<i>3.Operation,Maintenance Disposal stages</i>			
13. Lack/absence of regular and/or proactive maintenance			

**Root Causes and Impacts of Frequent Excavations to existing City Infrastructure:
A case of Addis Ababa Street and Utility Assets**

14. Overload/miss-utilization of infrastructures beyond their design capacity and/or their purpose			
15. Absence/poor implementation of initiatives such as SUE,MTU/urban underground space utilization & advanced technologies such as GPR, etc.			
16. Damage due to Vehicular Strike and/or other explosive accidents			
17. Lack of cooperation, coordination and communication between infrastructural companies during planning, scheduling and implementing infrastructural works & before starting any excavation works			
II. Political actions/practices/leverages			
18. Lack/absence of transparent and inclusive decision making for infrastructural works			
19. Politicians promising for provision of new infrastructure as reward of more support and future vote /election('pork barrel') that will not be feasible and/or deliverable at good quality & reasonable time			
20. Undertaking unnecessary new and reworks of infrastructures pretending it as 'creating job opportunity'			
21. Unnecessary interference and urgent decision and/or making alteration by higher officials/politicians against technical requirements of infrastructure			
22. Diversion of resource allocated for public infrastructure to other private or group advantage			
III. Cultural and/or Behavioral practices			
23. Misuse of existing public infrastructure (e.g. as storage of construction materials, solid waste disposal place) for other purpose than the intended ones and/or poor handling of public assets			
24. Vandalism and/or theft acts to infrastructural assets			

Key:

FEECI= Frequent Excavations to Existing City Infrastructure
 GPR= Ground Penetrating Radar
 MTU= Mapping the underworld
 MUT= Multi-utility tunnel
 SUE= Surface Utility Engineering
 TT= Trenchless Technology

Write your ideas regarding the problem as supplementary and/or different from the above listed:
