THE ROLE OF ADDIS ABABA MESKEL SQUARE UNDERGROUND PARKING ON TRAFFIC FLOW

Fikadu Alemu Kasaye

A Thesis Submitted to the Department of Urban Planning and Design, School of Civil Engineering and Architecture

Presented in Partial Fulfillment of the Requirement for the Degree of Master's in Urban Planning and Design

Office of Graduate Studies

Adama Science and Technology University

June 2022

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DECLARATION

I hereby declare that the work which is being presented in this thesis entitled: **"The Role of Addis Ababa Meskel Square Underground Parking on Traffic Flow"** is my own work and has not been submitted to any university for a similar purpose. The references used in this thesis work are duly recognized by proper citations.

Fikadu Alemu Kasaye ____ _____ _____

Name of student Signature Date

RECOMMENDATION OF ADVISOR

I, the major advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled **"The Role of Addis Ababa Meskel Square Underground Parking on Traffic Flow"** prepared under my guidance by Fikadu Alemu Kasaye. Therefore, I recommend the submission of a revised version of the thesis to the department for further review and evaluation.

__ Prof. Samson Kassahun ____ _____ _____

Major Advisor Signature Date

APPROVE OF BOARD OF EXAMINERS

I, the advisor of the thesis entitled **"The Role of Addis Ababa Meskel Square Underground Parking on Traffic Flow"** by Fikadu Alemu Kasaye, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

_Prof. Samson Kassahun___ _____ _____

Major Advisor/Supervisor Signature Date

We, the undersigned, members of the Board of Examiners of the thesis by Fikadu Alemu Kasaye have read and evaluated the thesis entitled **"The Role of Addis Ababa Meskel Square Underground Parking on Traffic Flow"** and examined the candidate during the open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Urban Planning and Design.

_____ _____ _____

Internal Examiner one (Chairperson) Signature Date

_____ _____

Internal Examiner Two Signature Date

_____ _____

External Examiner Signature Date

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

_____ _____ _____

Department Head Signature Date

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School Dean Signature Date

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Office of Postgraduate Studies, Dean Signature Date

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ACRONYMS

CBD	Central Business District
UUI	Urban Underground Infrastructure
UUS	Urban Underground Space
MSUP	Meskel Square Underground Parking

ABSTRACT

The use of underground spaces for parking purposes was the most effective method of improving traffic flow and street congestion in the city. These days, lack of parking spaces is a major challenge in different sub-cities of Addis Ababa affecting traffic flow and causing serious traffic congestion. Therefore, the main objective of this research was to evaluate the role of the newly constructed Meskel Square underground parking facility on traffic flow. The research used both primary and secondary data sources to get both qualitative and quantitative data depending on the objectives selected. To evaluate the role of MSUP facility on traffic flow questionnaires were distributed to sample drivers and interview were conducted to all facility managers/workers. The respondents were asked to evaluate traffic flow conditions and availability of adequate parking lot before and after the construction of the facility and also they evaluated the adequacy and efficiency of the facility. In addition, all facility managers/workers were also interviewed to evaluate traffic flow conditions and availability of parking before and after the construction of the facility, and also evaluated the adequacy and efficiency of the facility. The result of data from the questionnaire was processed using percentages, tables, and figures and described and interpreted in descriptive text, table, and report forms. Analyses of the data from the questionnaire and interview clearly showed that there were no adequate parking lot and traffic flow was slow and congested in the area before the construction of the facility and traffic flow has improved after the construction of the facility. In addition, analyses of the data from the drivers and facility managers /workers clearly showed that the facility is providing adequate and efficient parking service to its customers. Therefore, lack of parking lot was one of the main causes of traffic flow and congestion problem in the Meskel Square area. Thus, traffic flow improvement in the area after the construction of the MSUP facility clearly showed that the facility has improved traffic flow and has played its role to improve traffic flow in the area. Furthermore, the research recommended that future utilization of underground parking lots and other urban underground infrastructures improves traffic flow, traffic congestion, frees up above ground spaces for other purposes and reduces overcrowdings and pollution in a city.

Keywords: *Traffic congestion, traffic flow, underground infrastructure, underground parking, urban underground space*

CHAPTER ONE

1. INTRODUCTION

Car parking is a serious problem affecting drivers, pedestrians, and the business community (Capitol, February 2012). Searching for empty parking spaces is also a reason for more traffic generation and congestion even a short time for searching a parking space would generate a considerable amount of traffic. The construction of underground parking facilities as a solution to parking problems in many urban areas has received increasing attention (Hunt et al., 2016). Underground parking solves many traditional problems related to urban parking congestion, pollution, land space, and security (Goel, Singh, & Zhao, 2012). In Addis Ababa, currently, the use of underground spaces for parking purpose is very weak, in the past; the use of underground parking was limited to building basements below residential and commercial buildings. Recently, the Addis Ababa city administration has completed the first largest underground parking project at Meskel square, accommodating both parking and shopping facilities combined. So, studying the role of the newly constructed MSUP facility on traffic flow helps to develop similar projects in other congested areas of the city. Therefore, the purpose of this study is to evaluate the role of the Addis Ababa Meskel square underground parking on traffic flow in the area.

1.1 Background of the study

Urbanization due to rapid population and economic growth will force cities to place infrastructure facilities and utility services underground in order to unlock above-ground spaces for other use. The urban underground space (UUS) refers to the space below the ground available for human development and utilization (Hunt, Makana, Jefferson, Rogers, & Technology, 2016). In recent decades, urban underground space has been used specifically for infrastructures such as underground parking, transportation, subways, walkways, shopping malls, and utility networks such as electricity, gas, water supply, sewage disposal, and communication cables (Von der Tann et al., 2020).

Traffic congestion is a widespread global phenomenon caused by high population density, the growth of automobiles and their infrastructure, and the proliferation of racing and distribution services (Reed, T, 2019).

The construction of underground parking facilities as a solution to parking problems in many urban areas has received increasing attention across the globe (Hunt et al., 2016). Similarly, underground parking solves many of the traditional problems related to urban parking, traffic flow, congestion, pollution, land space, and security (Goel et al., 2012). As with underground railways, the use of UUS for underground parking has been promoted as one of the solutions to parking provisions. It is believed that the first underground city car parks were built in Pittsburgh 1920s (Cui, Nelson, & Technology, 2019). Recently, the Addis Ababa city administration has completed the first largest underground parking project at Meskel square, accommodating both parking and shopping facilities combined.

Therefore, many countries around the world are developing and utilizing underground parking as a solution to parking problem in their cities, the purpose of this study is to evaluate the role of the Addis Ababa Meskel square underground parking on traffic flow in the area. Thus, the thesis evaluated traffic flow conditions in the area by comparing traffic flow data before and after the construction of the MSUP facility. Moreover, it evaluated the adequacy and efficiency of the parking facility. In addition, future utilization of underground parking and urban underground spaces can free up above-ground space for other purposes and improves city traffic flow and congestion, and other problems.

1.2 Statement of the problem

Addis Ababa is the fastest growing city in the country due to urbanization. The Addis Ababa Meskel square area before the construction of the MSUP facility traffic flow was very slow and congested mainly due to shortage of parking lots in the area. As a result, drivers were parking their cars illegally on-street, and inside Meskel Square affecting traffic flow and causing serious traffic congestion in the area. According to Brooke, 2015, study estimation shows that 14% of traffic density is created by searching for parking space and 50% of increase in congestion-related time loss on roads has been generated due to shortage of parking space.

The construction of underground parking facilities as a solution to parking problems in many urban areas has received increasing attention across the globe (Hunt et al., 2016). Currently, in Addis Ababa the use of urban underground space to solve traffic flow and congestion problems in the city is very weak, especially for transportation infrastructures such as car parking, subway, walkways, underground commercial centers, etc. In addition, I have found no research done in the country on the utilization of urban underground space to solve traffic flow and other infrastructure problems. Therefore, this thesis evaluates the role of MSUP facility on traffic flow in the area and evaluates the adequacy and efficiency of the facility. In addition, it reviews world urban underground space utilization experiences and adopts it for future utilization of the spaces in the country. The study focuses on the previously completed MSUP facility which is the first and largest underground project constructed by the city administration. The majority of the urban underground space utilization in Addis Ababa was building basements built below commercial and residential buildings for parking and storage purposes on small scale. This has a limited contribution to improve the city traffic flow and congestion problems. Thus, the result obtained from this study raises the city administrations' awareness of the role of MSUP facility on traffic flow and encourages future development and utilization of underground parking and other underground infrastructures in the city and in the country.

1.3 Objectives of the Study

1.3.1 General Objectives

To evaluate the role of Meskel Square underground parking on traffic flow.

1.3.2 Specific Objectives

1. To evaluate traffic flow conditions in the Meskel square area before and after the construction of the MSUP facility
2. To evaluate the adequacy and efficiency of the newly constructed MSUP facility;

1.4 Research questions

1. Has the MSUP facility improved traffic flow in the area?
2. Is the MSUP facility providing adequate and efficient parking service to its customers?

1.5 Significance of the Study

This study mainly focused on evaluating the role of Addis Ababa Meskel Square underground parking on traffic flow in the area. Overcoming traffic flow problems and congestion in Addis Ababa is a major challenge to the city. The utilization of underground parking lots can improve the city traffic flow problems and traffic congestion and, air and noise pollution in a city. Hence, the overall findings of the study raise the city administration's awareness about the role of underground parking and urban underground infrastructures to improve traffic flow and congestion problems in the city. In addition, this paper can also be used as a springboard for other researchers who want to study this issue further.

1.6 Scope of the research

This thesis dealt with the evaluation of the role of the MSUP facility on traffic flow in the area. The scope of the thesis was limited to the Meskel square area where there were parking lot and traffic flow problem before the construction of the MSUP facility. Therefore, among the many causes of traffic flow problem, only the role of the newly constructed MSUP facility on traffic flow was evaluated. Even though the scope of the research was limited to the Meskel square area and the role of MSUP facility on traffic flow was studied the outcome could be replicated to other congested junctions of the city as well to urban centers in the country.

1.7 Limitation of the study

The study targeted the newly constructed MSUP facility and its role on traffic flow in the area. Since the parking facility is constructed underground and it is the first large underground project in the city and in the country, so the thesis experienced the following limitations

- Since the facility is new and it is working below its capacity it was somewhat difficult to get the required data for the analysis
- It was difficult to find some of the managers/workers to get the necessary data

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Introduction

This part of the thesis presents a brief overview of urban underground parking development and uses, traffic flow and congestion. In addition, urban underground infrastructure development and utilization practices of selected countries around the world were presented. Therefore, the study is intended to contribute to bridging the utilization of urban underground space for parking and other infrastructure development and the utilization gap in Addis Ababa. The study evaluated the role of Addis Ababa Meskel Square underground parking facility on traffic flow in the Meskel Square area and it also recommended possible future utilization of underground parking and replicate the project in different parts of Addis Ababa to improve traffic flow problems and congestion.

2.2 Theoretical literature

2.2.1 Underground parking

Parking is one of the comprehensive components in land use appearing in residential, shopping and industrial areas, and is related to all kinds of trips occurring in traveling, shopping and leisure trips (Mersden, 2006). Parking contributes to the appearance of the city and its suburbs; Affects traffic and traffic operations, and is an important component of urban street and transit systems. Its potential affects the viability and competitiveness of commercial areas and the choice of route (Weant & Levinson, 1990). The lack of adequate parking in Addis Ababa leads to road safety issues and traffic congestion. In addition, parking is common on the streets, there are no major traffic priority lanes and no adequate attention is paid to non-motorized transport users. Road lanes and squares are heavily congested (Addis Ababa Transport Policy, 2011).

According to Hunt et al., 2016, the construction of underground parking facilities as a solution to parking problems in many urban areas has received increasing attention. Similarly, underground parking solves many traditional problems related to urban parking congestion, pollution, land space, and security (Goel et al., 2012).

Thus, underground parking is built in conjunction with underground shopping malls and other facilities (Goel et al., 2012). Therefore, in addition to using the conventional type of parking spaces, policy makers can consider future underground spaces development for parking and other uses to improve traffic flow and congestion as well as to free up above-ground spaces for other purposes.

2.2.2 Traffic congestion

Traffic congestion is a serious problem in all mega cities (Goel et al., 2012). The problem of traffic congestion in urban cities has become a major problem, and one-third of these traffic jams in the world are caused by cars looking for parking due to the imbalance of parking demand and space (Joseph YJ et al, 2015). Traffic congestion causes inefficient traffic flow and as a result high transport costs and travel time. Hence, a policy will be formulated to optimize the existing infrastructure and provide solutions to the current supply, taking into account the expansion of infrastructure that requires a high investment in the city (Addis Ababa's transport policy, 2011). Traffic congestion is a condition on road network that occurs as use increase and is characterized by slower speed, longer trip time and increase vehicular queuing (Robert and Kiunsi, 2013).

2.2.3 Cause of Congestion

Experience has shown that the need for parking for an automated mechanical car park is about one-third to one-third of the space required for a traditional slope park. Also, there is almost no risk of accidents as the warehouse is unmanned except for inspection and service activities. The most common example is road physical use by vehicles. When traffic demand is adequate, the interaction between vehicles slows down the flow of traffic, causing some congestion (Hayimanot, 2021).

2.2.4 Cost of underground parking facilities

It should be recognized that construction costs for UUS projects are generally much higher than for similar above-ground or above-ground projects (Kaliampakos, Benardos, Mavrikos, & Technology, 2016).

Though they require large initial investments which means they are almost always more expensive than those aboveground, the fact that construction costs for underground parking facilities are very high may reflect the unique ground conditions that exist on the site (Goel et al., 2012). Occupying the underground saves space aboveground.

Table 2.2 Cost comparison in the case of an urban mass transit system

Construction	Initial capital cost ratio	Total lifecycle cost ratio
Underground	3.2—4.5	0.4—0.5
Surface	1	1
Elevated	2—2.8	1.4

Source: (R. Sterling et al., 2012).

2.2.5 Urban underground space

Underground space refers to a space that is below the surface of the earth (Rönkä, Ritola, Rauhala, & Technology, 1998). Above-ground land is limited and in some respects a non-renewable resource. On the flip side, the ground underground is another useful dimension that can offer many more opportunities for construction and other uses, such as subway tunnels, road tunnels, underground utility lines, underground parking garages, underground warehouses, pedestrian crossings, and large basement buildings (Bergman & technology, 1986).

The scientific and equitable use of underground space helps to increase capacity, reduce traffic congestion, improve the urban environment, contribute to urban disaster prevention systems and make the city more lively, flexible and inclusive (Kohlstedt, 2015). For example, large facilities such as sports halls, communication centers, cinemas, cinemas, libraries, shopping centers, and operating theaters can be built underground. A good example of this is the underground school facility in the Netherlands (Admiraal & Cornaro, 2018).

In addition, underground space can be used to accommodate new facilities or existing ground facilities that are not compatible with the urban environment or the above-ground space that is not optimally used are relocated, thereby freeing up valuable ground land for other beneficial uses.

The use of underground space not only depends on its use but also needs to consider other aspects, especially legal and administrative, economic, social, safety and health, technical and geographic environmental issues. Not all underground structures are suitable for many Site, function, and building procedures, but under the right conditions, they can be used as an alternative to development (Carmody & Sterling, 1993).

2.2.6 Urban underground infrastructures (UUI)

Urban underground infrastructure (UUI) is defined as a series of underground structures that are physically or functionally interconnected (R. Sterling et al., 2012). According to Sterling et al., 2012, they are divided into two categories: 1. Functional infrastructure and 2. Passing and living spaces.

2.2.6.1 Functional infrastructures

These include utilities (water, energy, waste, sewage, and telecommunications), storage facilities (natural gas, food, and oil), and energy development systems (geothermal boreholes) (Li, 2013). These facilities are designed to smoothly deliver resources and surplus output through the city, and support the city's daily functions. This section will only review the passage and living space of the Urban Underground Infrastructure (UUI) (R. Sterling et al., 2012).

2.2.6.2 Passing and living spaces

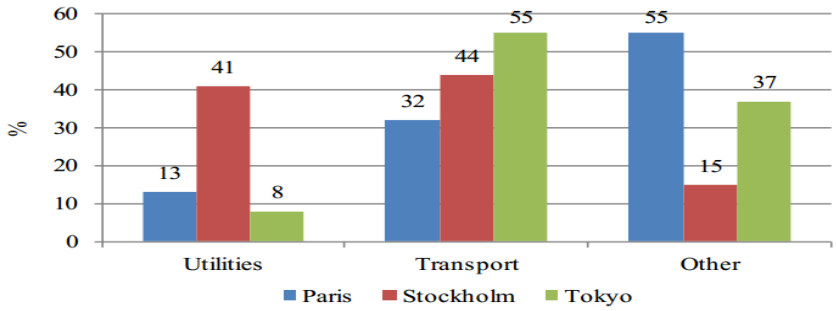
This category includes for example transportation networks (subway and road tunnels), underground stations (parking lots, subways, and buses), and underground leisure centers (shopping centers, sports facilities, theaters, museums, and libraries). These infrastructures provide space for human activities, which are usually “traveling” or short stays without disturbing the outdoor environment (Jefferson, Rogers, & Hunt, 2006).

Passing and living spaces are further classified into two groups 1. Transportation network and 2. Entertainment use

2.2.6.3 Transport network (subway or road tunnel)

A study on the transportation network of three cities—Paris, Tokyo, and Stockholm (Figure 2.5) shows an example of the widespread use of UUS based on public utilities, transportation, and other uses (such as public spaces, shopping areas, garages, warehouses, and industrial uses). Research shows that transportation and public utilities are the most common functions of UUI (Bobylev, 2009).

Figure 2.1 UUS use by function



Source: (Bobylev, 2009).

2.2.6.4 Recreational use (Shopping centers, sports, theatre)

Over the past 50 years, various premises have been moved underground to provide more comfort in densely built-up areas or to create a more welcoming environment on the ground (Vähäaho, 2011). A wide variety of facilities can be built underground, such as sports facilities, communications centers, cinemas, theaters, libraries, shopping centers, and even operating theaters.

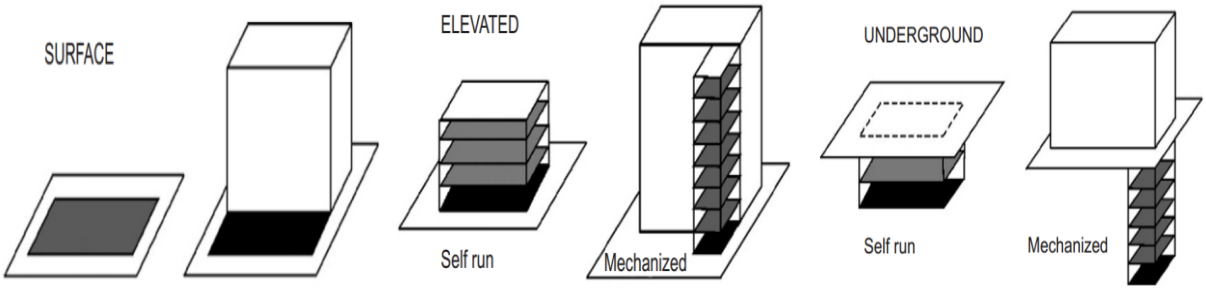
2.2.7 Types of parking facilities

According to Fukuchi, 1994, parking facilities may be divided into the following three groups, based on their location in relation to the surface Fig. 2.3. The first type of parking facility is surface (flat) structure, second above ground (elevated) structure, third underground structure (Fukuchi, 1994). Depending on whether the vehicle is driven into its parking space by mechanical means or by its force, the final two parking structures can be further classified as mechanical or non-mechanical (Fukuchi, 1994).

Unlike a traditional self-driving system, mechanized parking systems allow drivers to move their cars to and from the parking lot automatically. Experience has shown that the need for parking for an automated mechanical car park is about one-third to one-third of the space required for a traditional slope park.

Also, there is almost no risk of accidents as the warehouse is unmanned except for inspection and service activities (Kaliampakos et al., 2016).

Figure 2.2Types of parking facilities based on their location



Source: (Fukuchi, 1994).

2.2.8 Evaluation criteria of a site for underground parking

According to Godard, 1995, the underground parking site can be evaluated on the basis of the following criteria. Accessibility (Is the site on a main car traffic route? Will vehicles driving in and out cause congestion? Is public transport to important points in the city center available?), the other criteria's were parking situation (Is there a high demand for parking at the site or in the area directly surrounding it, showing that a car park is needed? Has parking control already been introduced?), function for visitors were also (How many functions that attract the public and how much shopping space is located within range of a car park on that site?

For the moment, this range is assumed to extend out to a maximum walking distance of 500 m.), Function for residents (How many residents live within 500 m walking distance of the site?), Relationship of the site to existing carports (To what extent do the ranges of existing and already planned public car parks overlap with the range of the site under consideration?),

Relationship with the intensification of land use (Can an increase in the need for parking spaces in the immediate surrounding area be anticipated due to the construction or redevelopment of buildings?), Zoning plan (Do the conditions set forth in the zoning plan permit construction of a car park?)

2.2.9 Parking Problems in Addis Ababa

The challenges of parking space in urban cities are said to be due to urbanization, rapid increase in car dependence, high density of the city and economic transition (Shoup, 2005).

The Addis Ababa City Administration has formulated a strategy to develop parking spaces throughout the city to address the shortage of parking spaces, and the administration will build parking facilities in the short term. However, for unknown reasons, the city is still moving without adequate parking spaces. Parking is a serious problem affecting drivers, pedestrians, and the business community (Capital magazine in February 2012). As a result, the lack of adequate parking spaces has led to inefficient use of the road system, resulting in safety hazards, traffic jams, and congestion (Agyapong, 2018). Thus, parking is one of the critical issues that need to be addressed immediately through the city's optimal transportation plans (Banister, 2001).

2.2.10 The underground space planning challenge

The following challenges are the commonly faced challenges while developing UUS. Adopted from (Jayeshkumar, B., & Sanjukkta, M 2019).

2.2.10.1 Lack of policy

The lack of policy underground policy in most countries is creating problems in the development of UUS. In developed countries, this underground space is the property of the landlord until valuable resources are found. Compensation law also applies to underground spaces.

2.2.10.2 Cost of underground construction

Underground construction is a costly affair while developing underground space.

There are two types of costs that should be considered while developing underground space, one is the direct cost and the other is the sustainable cost associated with the project that the project needs to deal with.

2.2.10.3 Integration of aboveground and underground activities

During underground space development integration between underground and above-ground activities is a major challenge in the design of underground spaces.

2.2.10.4 Mind-set

Underground space design is a multi-disciplinary subject a human mentality must be rational to use land resources effectively and to regulate pressure on different types of land use.

2.2.10.5 Lack of skilled manpower

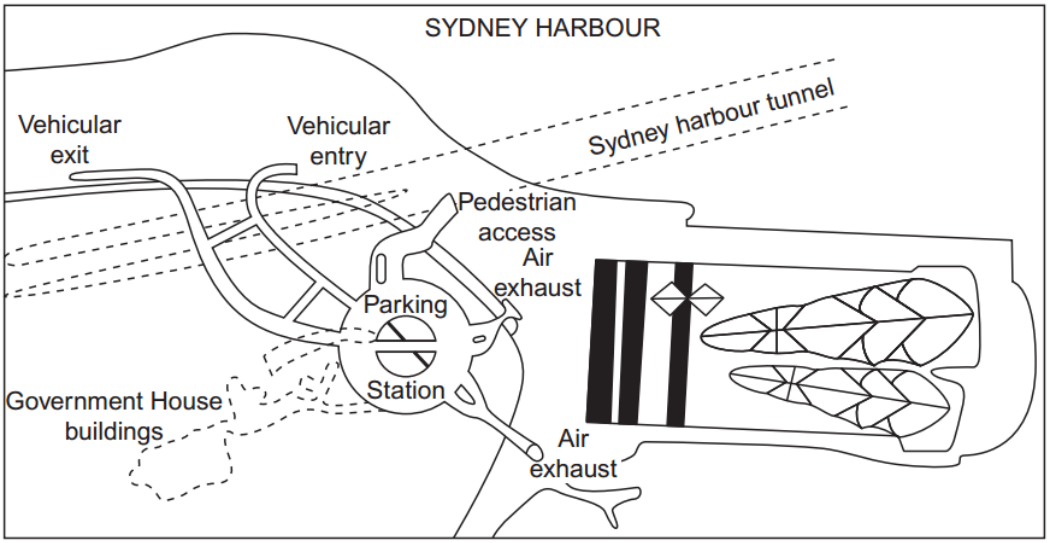
The shortage of skilled manpower and human resources makes underground space development a major challenge.

2.3 Empirical literature

2.3.1 Sydney opera house underground car park

The Sydney Opera House is an important landmark in Sydney's historic area. Its location at Bennalong point is a spectacular view of the Sydney Harbor Bridge, adjacent to the Government House and the Royal Botanic Gardens Figure 2.3. These features, in addition to its impressive architecture and well-known cultural location, attract many visitors each year, attracting 1.4 million Opera House sponsors and 2 million visitors to the Opera House (Pells, 1993).

Figure 2.3 Location plan of the Sydney Opera House underground car park

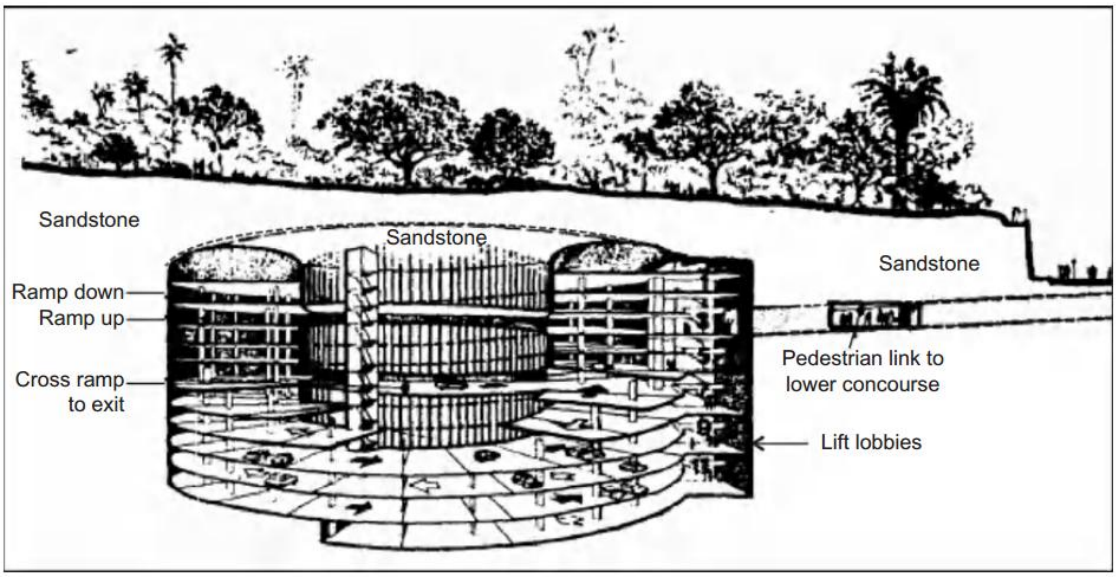


Source: (Pells, 1993).

This is the first helical underground parking lot with 12 floors and 1100 parking spaces Figure 2.4. It consists of a free-standing double-helix concrete structure wrapped around a central new center with link drive and service tunnels. The large, donut-shaped cave is 71.2 m in diameter on the outside and 36.4 m on the inside. The structure is 32 m high and extends about 28 m below sea level. Vehicle access to the parking lot is via a tunnel from Macquarie Street, passing through the top of the Sydney Harbor Tunnel. This limit dictated that the cave be built as close as possible to the ground surface (Godard, 1995).

In order to avoid diminishing the aesthetic appeal of the area, all work had to be done without disturbing the surface in the Botanical Garden or in front of the Opera House. As these environmental barriers prevented the cut-and-cover system, the car park was built entirely underground in the Royal Botanic Gardens. One element of the design was that the fig trees above the car park did not affect its construction or functionality (Pells, 1993).

Figure 2.4 Architect's sketch of the double-helix Sydney Opera House underground car park



Source: (Pells, 1993).

The rock cover above the cave is 7-9 m thick, and the Royal Botanic Gardens are covered with various meteorological Sydney sandstones ranging in size from 1 to 2 m.

Does not provide long-term support to the helical concrete structure Rock cover; its largest unsupported range is 17.4 meters. Various challenges related to the design and construction of these car parks have been reported at conferences and in the technical literature (Pells, 1993). This world-famous case study sheds considerable light on the advantages of underground structures in achieving simultaneous conservation solutions. Meet parking requirements related to the environment and often visited public places.

Therefore, world urban underground space development experiences clearly shows that urban underground space can be used placing all building functions that can be placed above ground. The Sydney opera house underground car parking development experience shows that underground space can be used for parking purposes, as substitute to conventional type of parking, surface parking and elevated type of parking's. In developing countries utilization of urban underground space for parking and other infrastructures is purposes is very week due to unavailability of technology, skilled man power and its high development cost.

The recently completed MSUP facility in the Meskel Square area is a successful underground parking project developed and constructed mostly by Ethiopian engineers and can be used as a role model for other underground parking and underground infrastructure development in the city and in the country (Pells, 1993).

2.3.2 World urban underground space development

The following table shows the various recent urban underground space development practices and suggested strategies for future utilization of these spaces. Adopted from (Gamayunova & Gumerova, 2016).

Table 2.3 Successful development of underground space around the world

Underground city, country	Location	Construction objects on the territory of the underground city	The problem, solved by the underground city
1.Germany	Under the area of survived the reconstruction the Reichstag	Offices, shopping centers, parking lots	Reduction of pedestrian and vehicle flows, providing Berlin an additional useful area for business and the entertainment part of the city
2."PATH", Canada	Under the area of Toronto city center	27 km of shopping arcades, 5 metro stations, 20 car parking, 2 major department stores, 6 major hotels, and a railway terminal. The shopping area 371, 600 sq. m	Saving urban areas intended for the building of objects of social infrastructure. Transitions and galleries connect the PATH to the business centers, residential complexes, metro stations and railway stations. The reduction of car traffic
3."RESO", Canada	Under the area of the business part of Montreal	Entertainment centers, cinemas, banks, restaurants and hotels	Infrastructure fully meets the needs of modern man Tunnels with a length of 32 kilometers connecting the business part of town to the train stations, bus stations and metro lines
4. La Ville souterraine, Canada	Under the area of Montreal city center, 12 million sq. m	Shopping centers, hotels, banks, museums, universities, metro, rail hubs, road station	The city includes the objects of entertainment and business infrastructure, which meets almost all the needs of life
5.Yaesu, Japan	Under the area of the Central terminal station of Tokyo 68, 000 sq. m	About 250 shops, restaurants, banks, and insurance companies. Parking space for 570 cars	The city is visited by 8-10 million people every month. Yaesu accommodates objects of business and entertainment infrastructure, ensuring a comfortable pastime for the urban dweller. There is a system of preferential taxation for people

			working under the ground. The city is also attractive to tourists
6.London, UK	The House of Vans Skate park	Skate park	To bring communities of the area together, the subterranean the skate park was built and is spacious enough so that skateboarders can spend a lot of time practicing.
7.London, UK	The Vaults Theatre	theatre	A theatre located under the railway arches beneath Waterloo Station.
8.Helsinki, Finland	Quarried out of the solid rock	Itäkeskus Swimming Hall and Civil Defense Shelter	The underground swimming hall and gym have facilities on two levels that can accommodate around a thousand visitors at a time. Quarried out of the solid rock, the hall can be converted into an emergency shelter.
9.Helsinki, Finland	Located 30m below Hakaniemi Market	Arena Center Hakaniemi and Leikkiluola Indoor Playground	Located 30m below Hakaniemi Market, the facility has four indoor courts for playing floor ball, futsal, handball, and badminton.
10.Gothenburg, Sweden	West Link	8-km railway line	Upon its completion in 2026, this 8-km railway line, of which 6 km are in a tunnel, will increase the capacity of the railway system in the Gothenburg region which has already reached its maximum capacity.

Adopted from (Gamayunova & Gumerova, 2016)

There are many benefits to going underground. In particular, for sites in the city center or central business district (CBD), land cost savings would result in a much lower budget for an underground project than an underground project (R. L. Sterling & Godard, 2000). In Shanghai, China, for example, more than 2 million m^2 of underground buildings have been developed for various uses since the 1980 renovation. Facilities such as underground supermarkets, warehouses, silos, garages, hospitals, markets, restaurants, cinemas, etc. can be found throughout Shanghai, including hotels, entertainment centers, factories and workshops, cultural farms, plantations, tunnels, and water tunnels (Xueyuan, Yu, & technology, 1988). Thus, this development experience clearly shows that in addition to infrastructure and utility services, all functional buildings can be placed underground if it is properly designed, and constructed.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Introduction

The main purpose of this chapter is to present the underlying principle of research design and methodology, sampling design, data and information sources, the selection of appropriate data collection techniques and the method of data analysis are presented in line with thesis questions proposed prior to the study.

3.2 Description of the study area

Meskel Square is located at the center of the crowded city of Addis Ababa having a square meter of 41,245 and a perimeter of 934 meters (Tadesse, & Erçin, 2021).

3.2.1 Meskel Square before the construction of the MSUP facility

The Meskel Square before the construction of the MSUP facility were consisting of some activities categorized into cultural, political, religious, and everyday activities. Figure 3.2 and 3.3 below shows that the square before the construction of the MSUP facility was used for many activities such as car parking, bus terminal, sporting activities, etc. These activities were affecting traffic flow in the area by causing traffic congestion. The renovation of the area and the construction of the MSUP facility avoided the above activities which were affecting traffic flow in the area (Tadesse, & Erçin, 2021). Therefore, the purpose of the thesis was to evaluate the role of the MSUP facility on traffic flow in the area.

Figure 3.3 Zoning of Meskel Square before the construction of the MSUP facility

Source: Taken from (Tadesse, & Erçin, 2021)

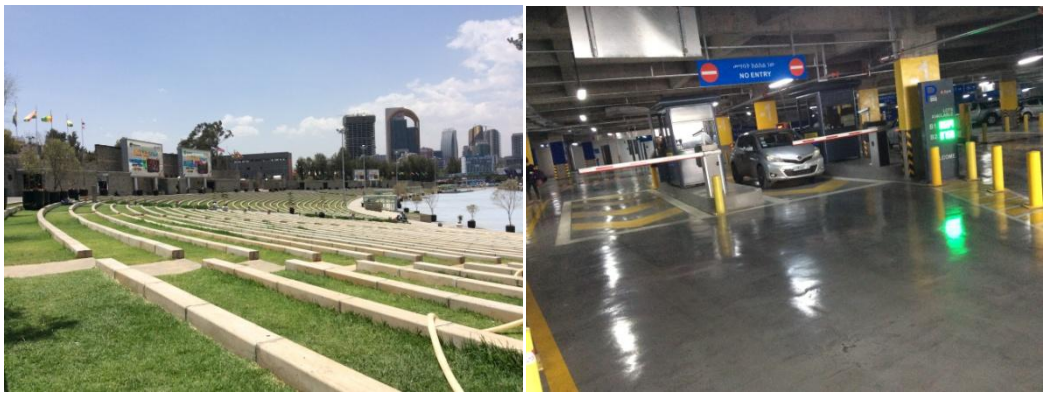
Figure 3.4 Parking in the square before the construction of the MSUP facility

Source: Taken from (Tadesse, & Erçin, 2021)

3.2.2 The Meskel Square at present

Renovation of the Meskel Square created an artificial lake, moveable trees, artificial lights, and a massive underground parking lot with the capacity to accommodate approximately 1,400 vehicles. It is designed to allow vehicles to travel under the surface of the square leaving the ground level free for pedestrians and recreation and other purposes. The project also included six LED screens and around 30 retail shops, a library, a café, and restaurants (www.capitalethiopia.com).

Figure 3.5 Meskel Square after renovation



Source – Own Survey (2022)

3.2.3 Traffic flow in the area of the MSUP facility

Meskel Square area being the center of the city, has six approach legs, Bole Airport, Megenagna, Main Palace, Arada, Mexico, and Akaki approaches were experiencing a serious traffic flow problem and congestion before the construction of the MSUP facility which was affecting drivers' daily activity. Therefore, the objective of this thesis was to evaluate the role of the newly constructed MSUP facility on traffic flow in the area.

Figure 3.6 Meskel Square approach streets

Source: Taken from (Aragaw, 2011).

3.3 Research design

The study considered adopting both qualitative and quantitative techniques in analyzing the study objectives and addressing the research questions raised above. The research aimed at studying the role of the MSUP facility on traffic flow in the Meskel Square area. After a literature review, a questionnaire was designed to collect data from the respondents.

The thesis evaluated the role of the MSUP facility on traffic flow in the MSUP facility area, and the adequacy and efficiency of the MSUP facility. The methodology employed here is a descriptive analysis where the sources of the data were both primary and secondary data. The primary data was obtained from drivers using questionnaire, who knows the area before and after the construction of the facility and currently using the facility.

In addition, interviews of all MSUP facility managers/workers were also conducted to evaluate traffic flow condition and availability of adequate parking lots before and after the construction of the facility. In order to evaluate the role of MSUP facility on traffic flow, the thesis used driver's and interview responses to compare traffic flow and parking conditions in the area before and after the MSUP facility. In addition, drivers and facility managers/workers responses were analyzed to evaluate the adequacy and efficiency of the facility. The study used secondary data for the literature review. The secondary data were obtained from different scholarly written literature such as journals, articles, policy reports, and books.

3.4 Sources of data and research instruments

In order to achieve the objectives of the study, both primary and secondary data sources were used to get qualitative and quantitative data depending on the objectives selected. The secondary data will be obtained from different scholarly written literature such as journals, articles, policy reports and books.

The primary data were obtained through questionnaires that were distributed to drivers who know the area before and after the construction of the MSUP facility and currently using the MSUP facility. Thus, the questionnaire was distributed within the facility to 165 sample drivers selected among daily average 282 drivers who parked their cars in the facility. In addition, all facility managers/workers were interviewed to evaluate traffic flow and parking conditions in the area before and after the construction of the facility and also evaluated the adequacy and efficiency of the facility.

3.5 Sample and sampling techniques

To achieve the objective of the research drivers and all facility managers/workers of the MSUP facility were surveyed using a questionnaire and interview respectively. The purposive sampling technique was used to select the drivers who used the MSUP facility and know the Meskel square area well before and after the facility. Therefore, among the drivers who used the MSUP facility sample drivers were selected purposefully inside the facility to get the necessary information. According to Walliman (2005), purposive sampling is a useful sampling method that allows a researcher to get information from a sample of the population that one thinks knows most about the subject matter.

To determine the sample size of drivers, according to the controller of the MSUP facility the average daily parked car in the MSUP facility was 282, to determine the minimum sample size of drivers among 282 drivers who parked their cars daily in the facility; the Slovene's formula was used; which states as follows:

$$n = \frac{N}{1+N(e^2)} =$$

Where: n is the sample size, N is the population size and e is the margin of error. A level of confidence of 95% and a margin of error (e) of 0.05 were used to determine sample size. Putting those values in the formula, the sample size for the drivers was calculated as: $n=282/1+282(0.05)^2=165$. The time for the collection of information from drivers ranges from 2.00 am to 2.00 pm (twelve hours). Within which the traffic flow will be at its peak. Hence, the respondents were selected in such a way that every driver in the facility will have an equal chance of being included in the survey, thus, 12 hr/165= 720min /165=4.4 min interval within the specified period questionnaire was distributed to drivers inside the facility and collected.

3.6 Data collection

In general, after the designing of the data gathering tools, the pre-testing of the questionnaire was carried out to see whether the items could generate the expected data or not, and based on the information obtained, the questionnaire were refined further and were distributed to the respondent. As indicated in data gathering tools to address the objectives of the study first, a questionnaire was distributed to drivers who know the Meskel Square area to evaluate traffic flow and availability of parking lot in the area before and after the construction of the facility and also evaluated the adequacy and efficiency of the facility. In addition, MSUP facility managers/workers were also interviewed to evaluate traffic flow and availability of parking before and after the facility and also evaluated the adequacy and efficiency of the MSUP facility.

3.7 Methods of data analysis

As it can be seen from the above discussion, mainly questionnaire and interview was used to obtain data for the thesis. The analyses of the data from the questionnaire were carried out using descriptive statistics. The results of the questionnaire were described qualitatively and quantitatively and the findings were summarized.

The gathered data was presented in the form of graphs and tables in order to ensure a clear presentation and better understanding of the situation. The result of quantitative data was processed using percentages, figures, and tables. And for the qualitative data, the analysis result was described and interpreted in descriptive text, table, and report forms.

Hence, the analysis processes clarified the role that the Meskel Square underground parking played on the traffic flow in the area and the results of the analysis helped to formulate recommendations for possible future underground parking development and utilizations of UUS in the future by city administration.

CHAPTER FOUR

4 RESULTS AND DISCUSSION

The analyses of the data from the questionnaire and interview were carried out using descriptive statistics. The results of the questionnaire from drivers and facility managers/workers were described qualitatively and quantitatively and the findings were summarized. The gathered information was presented in the form of charts, graphs, and tables in order to ensure a clear presentation and better understanding of the situation. The result of quantitative data was processed using percentages, figures, and other statistical tools. And for the qualitative data, the analysis result was described and interpreted in descriptive text, table, and figures.

4.1 Demographic data of drivers

The total number of sample drivers who participated to respond to the questionnaires was 165 among these 162 returned the questionnaires, which were 98.2 % of the total respondents. Among the 162 participants, 74.7 % were males and 25.3 % of them were females. As shown in table 4.1 below age is a very important criterion for driving a car, 51.85 % of the drivers' age ranges from 31-to 40 years, and 23.45% the second highest scored age and the interval was18-30 years. Furthermore, 14.81% and 9.89% were age intervals 41-50 and 50+ respectively. Hence, the majority of the driver's age range is between 31-40 years which means that majority of the drivers are mature enough to give reliable information about the thesis questions on traffic flow and on the adequacy and efficiency of the MSUP facility.

Table 4.1 Demographic data of drivers

Biographical details of drivers							
		Fr	**PCT %**			**Fr**	**PCT %**
Questioner	Distributed	165	100	**Education level**	Certificate	23	14.23
	Returned	162	98.2		Diploma	36	22.2
Gender	Male	121	74.7		BA/BSC	52	32.10
	Female	41	25.3		MA/MSC	14	8.64
Age in years	18-30	38	23.45		PhD	2	1.23
	31-40	84	51.85		Other specify	35	21.6
	41-50	24	14.81				
	50+	16	9.89				

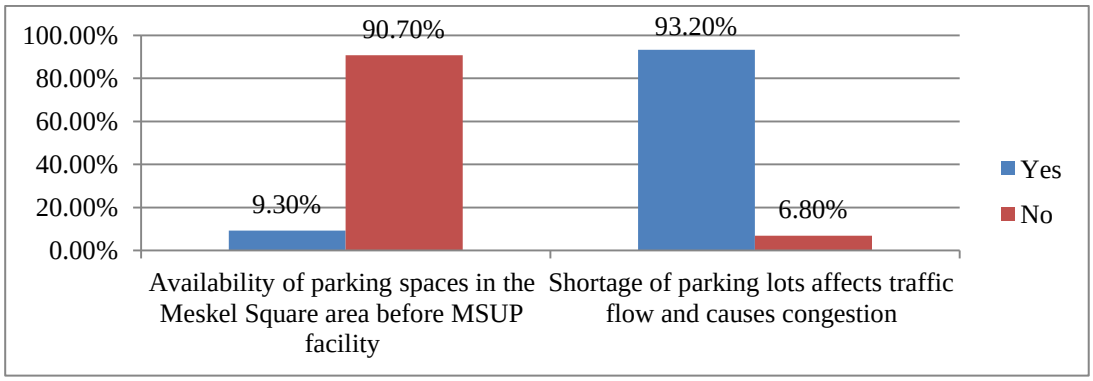
4.2 Analysis of questionnaires on traffic flow and adequacy and efficiency of the facility

The purpose of the survey was to evaluate the role of the MSUP facility on the traffic flow in the Meskel Square and also to evaluate the adequacy and efficiency of the facility. Questionnaire was distributed to drivers who know the Meskel Square area to evaluate traffic flow and availability of parking lot in the area before and after the construction of the facility and also evaluated the adequacy and efficiency of the facility. In addition, MSUP facility managers/workers were also interviewed to evaluate traffic flow and availability of parking before and after the facility and also evaluated the adequacy and efficiency of the MSUP facility. .

4.2.1 Availability of parking lots and its effect on traffic flow before MSUP facility

The survey result from drivers and in interview clearly showed that there were no adequate parking lots in the Meskel Square area before the construction of the MSUP facility. Figure 4.1 below shows that 90.7% of the drivers responded that there were no adequate parking lots in the Meskel Square area before the construction of the MSUP facility, while the remaining 9.3% of the drivers responded that there was parking lot before the MSUP facility. This means that the lack of adequate parking spaces forced people to park their cars illegally on the street; as a result it narrowed the street and affected traffic flow in the area. In addition, Figure 4.1 below shows that 93.2 % of the drivers responded that the shortage of adequate parking lots in the Meskel Square area before the construction of the MSUP facility affected traffic flow and caused street congestion in the area, while the remaining 6.8% of the drivers disagreed. Thus, the result clearly showed that lack of adequate parking lots in the Meskel area affected traffic flow and caused traffic congestion in the area before the construction of the facility; inadequate parking lot in the area and due to many other reasons the area was experiencing slow traffic and congestion.

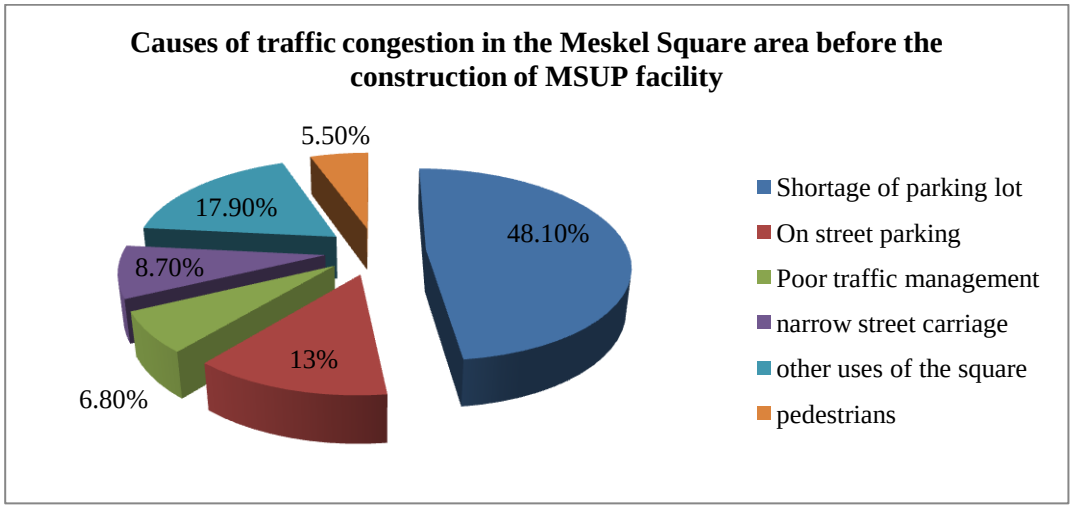
Figure 4.2 Availability of parking and its effect on traffic before MSUP



4.2.2 Causes of traffic flow problems and congestion before MSUP facility

According to drivers and facility managers/workers the main causes of traffic flow and congestion problem before the construction of the MSUP facility were shortage of car parking lot in the area. Figure 4.2 shows 48.1% of the drivers responded that shortage of parking lot was the main cause of traffic flow and congestion problem in the area and 17.9% of the drivers responded that the other uses of the square (sporting activity, parking lot, bus terminal, and other functions) were the second main causes, the other main causes were on street parking 8.7%. Poor traffic management and pedestrians were also the other causes 6.8% and 5.5% respectively. Therefore, the construction of the MSUP facility has solved parking lot problem which was the main causes of traffic flow and congestion problem in the area.

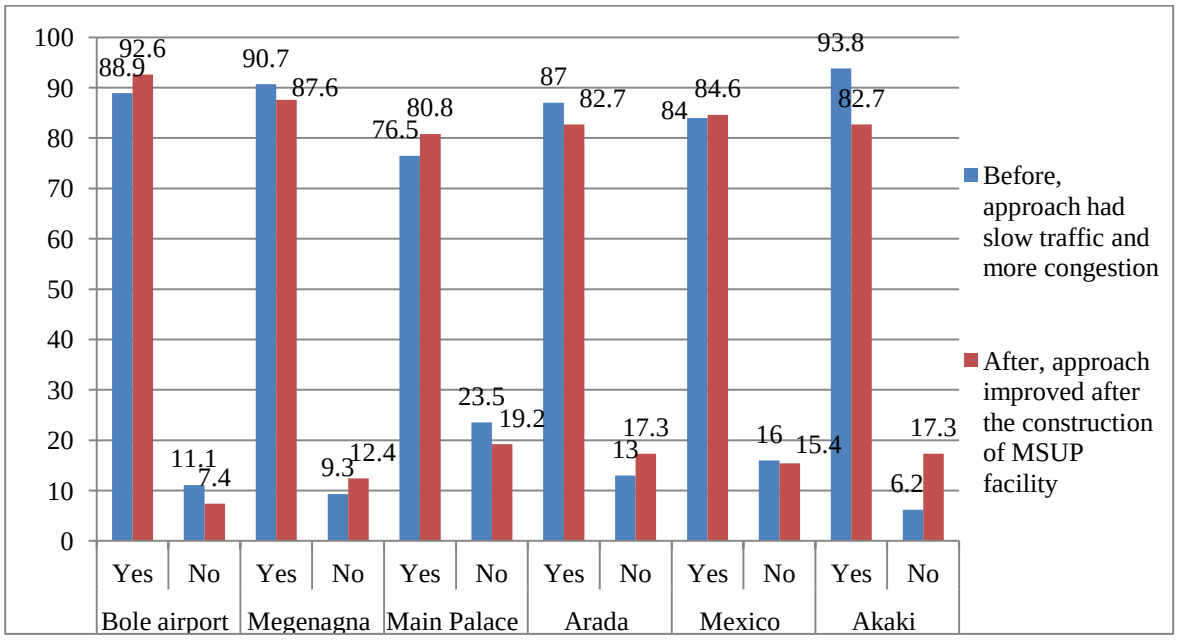
Figure 4.3 Causes of traffic congestion in the Meskel Square area



4.2.3 An approach street to Meskel Square which was congested before and improved after the construction of the MSUP facility

According to drivers and facility managers/workers all the six approaches to the Meskel Square before the construction of the MSUP facility were congested especially the Akaki, Bole airport and the Megengna legs were very congested, the other three were relatively better. In addition Figure 4.3 clearly shows the existence traffic and congestion problem before the construction of the MSUP facility, and traffic flow and congestion improvement after the construction of the MSUP facility in the area, according to drivers more than 85% of the respondents agreed that there was traffic and congestion problem in all approach legs to Meskel Square before the construction of MSUP facility. Furthermore, figure 4.3 shows more than 80% of the drivers responded traffic flow and congestion has improved in all approaches after the construction of the MSUP facility.

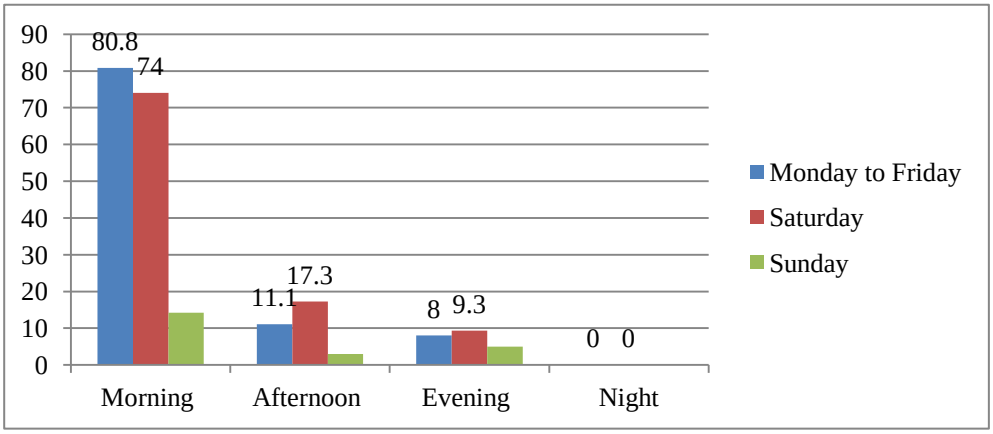
Figure 4.4 An approach street to Meskel Square which was congested before and improved after the MSUP facility



4.2.4 Days and times in which traffic was congested before the MSUP facility

As shown in Figure 4.4 80.8 % of the drivers responded that from Monday to Friday and during the morning hour's traffic flow was slow and congested in the area, 11.1 % and 8 % of them responded that there were congestion during afternoon hours, and evening hours respectively. On Saturday, 74 % of the drivers face slow traffic and congestion during morning hours, 17.3 % face slow traffic congestion during afternoon hours and 9.3 % face congestion during evening hours. On Sundays, only 14.2 % of the drivers responded during morning hours there is slow traffic and congestion, and 3 % and 5 % of the drivers responded there is congestion in the afternoon and evening hours respectively. Hence, before the construction of the MSUP facility most of the drivers face congestion during weekdays and Saturdays in the morning hours.

Figure 4.5 Time of the day in which traffic was congested before MSUP facility

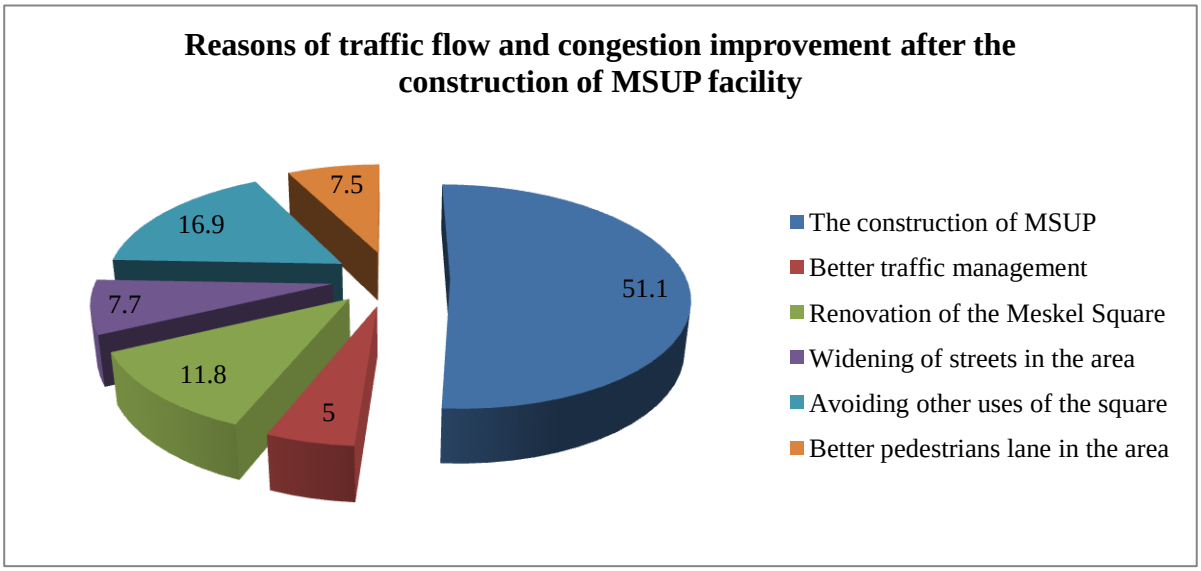


4.2.5 Reasons for traffic flow and congestion improvement after MSUP

According to drivers' and facility managers/workers, the main reason for traffic flow and congestion improvement of in the area was the construction of the facility, the renovation of the Square, preventing other uses of Meskel Square, the construction of better pedestrian lane in the area, and better traffic management. Figure 4.5 shows 51.1% of the drivers responded the construction of the MSUP facility has improved traffic flow and congestion problem in the area, while, 16.9 % and 11.8 % of the drivers responded that preventing other uses of the square and, renovation of the Meskel Square respectively also has improved traffic flow and congestion in the area.

In addition, drivers and facility managers/workers suggested that placing appropriate traffic symbols, educating drivers, widening roads, and constructing pedestrian lanes could improve traffic flow and congestion in the area.

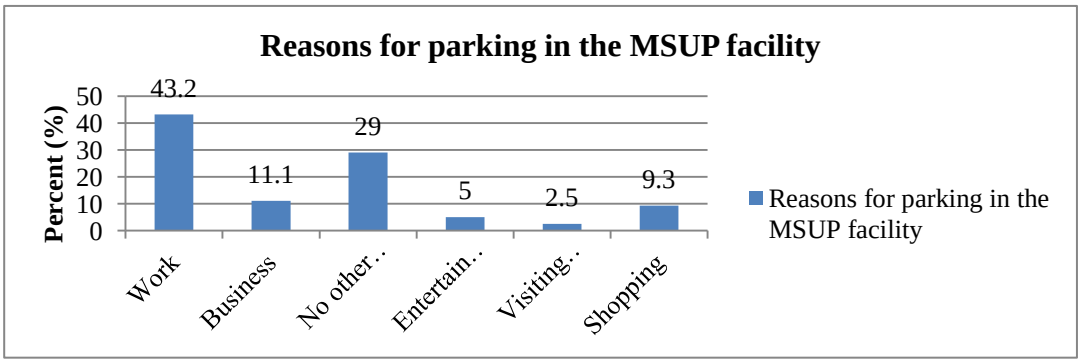
Figure 4.6 Reasons for traffic congestion improvement after MSUP facility



4.2.6 Drivers' reasons for parking in the MSUP facility

Figure 4.6 shows the main reasons for drivers parking their cars in the facility during the studied period. Accordingly, drivers parked their car in the facility for work purposes 43.2 %, because there is no car parking in the area 29 %, for business purposes 11.1 %, for shopping purposes 9.3 %, for entertainment purposes 5%, and the remaining 2.5 % for visiting families and friends. This means that most of the drivers parked their car in the facility for work, and business, and because there is no car parking lot in the area 83.3 %, this indicated that the Meskel Square area is a centre for work, business and different commercial activities and attracts a large number of customers for different purposes including shopping and entertainment purposes. Therefore, the city administration needs to take additional measures to improve parking options, traffic flow and congestion in the area so that the area becomes a commercial hub of the city.

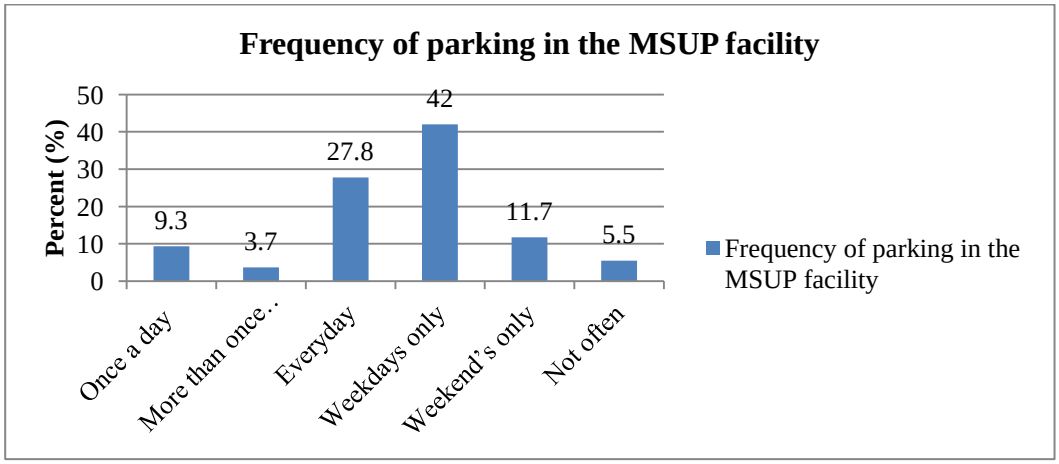
Figure 4.7 Drivers' reason for parking in the MSUP facility



4.2.7 Frequency of parking in the MSUP facility

Figure 4.8 clearly shows that 42 % of the drivers visited the MSUP facility during weekdays, 27.8 % of the drivers visited the MSUP facility every-day, 11.7 % of the drivers visited during weekends only, 9.3 % of the drivers visit the area once a day and the remaining 3.7 % and 5.5 % more than once a day and do not often park their cars in the MSUP facility respectively. Thus, most of the drivers visited the facility every day. Which means majority of the drivers know the area very well so, we can rely on the information provided by them about traffic flow and the adequacy and efficiency of the facility.

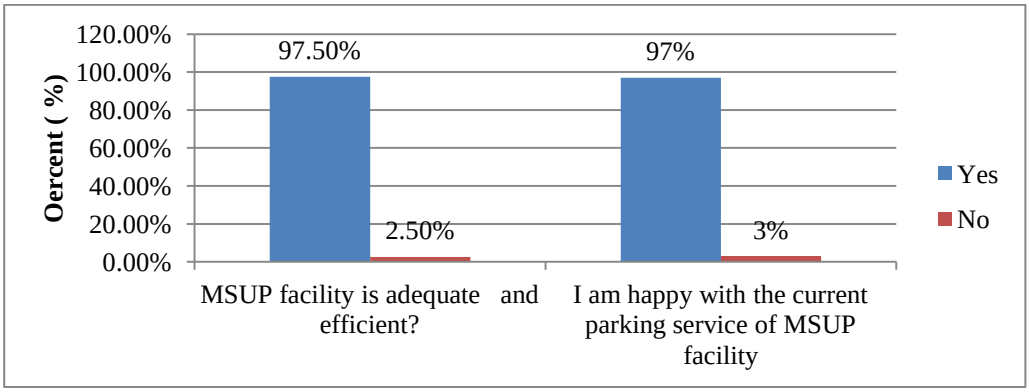
Figure 4.8 Frequency of parking in the MSUP facility



4.2.8 Adequacy and efficiency of MSUP facility and satisfaction of drivers

According to drivers' and facility managers/workers, there is adequate parking spaces in the facility which can accommodate present parking demand in the area and efficient. Figure 4.10 shows that 97.7 % of the drivers responded that the MSUP facility has adequate and providing efficient parking service in the area. Furthermore, figure 4.8 shows that 97 % of the drivers were satisfied with the current MSUP facility parking services due to its adequate parking lots, efficient service, convenient parking options, and efficient parking configurations. All the drivers gave positive answer about the facility service. Finally, the facility is new to the city and to the country; so it needs more advertisement to attract customers.

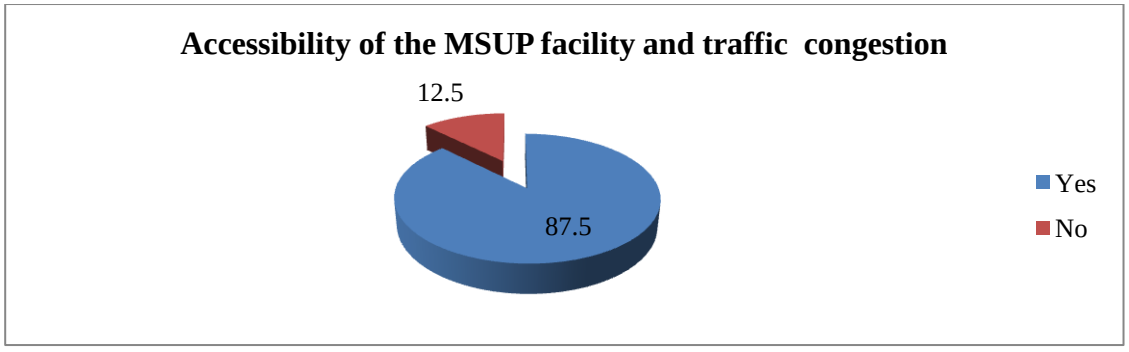
Figure 4.8 Adequacy and efficiency of the MSUP and satisfaction of drivers



4.2.9 Accessibility of MSUP facility

As shown in the figure below 87.5 % of the drivers responded that the facility is accessible and did not cause any traffic flow problems and congestion in the area while 12.5 % of the drivers responded that the facility has accessibility problems while entering and leaving the facility.

Figure 4.9 Accessibility and traffic congestion



4.3 Discussion

4.3.1 Traffic flow conditions in the Meskel square area before and after the construction of the MSUP facility

According to drivers and facility managers/workers, among the many causes of traffic congestion in the MSUP area shortage of parking lot was the major one. The renovation and the construction of the MSUP facility have improved parking problem and traffic flow and congestion in the area. According to Ishioka, 1992, the growing number of automobiles in Japan has caused serious parking problems, such as a lack of parking spaces and illegal parking on public roads, especially in the city centers. Traffic congestion is a condition of the road network that occurs with increasing usage and is characterized by slower speeds, longer travel times and increased queues (Robert and Kiunsi, 2013). According to Goel et al., 2012, the progressive increase of the number of cars parked on the roadside and often on pavements has caused a significant decrease of the road space available to both moving vehicles and pedestrians. Moreover, the growing number of automobiles in Japan has caused serious parking problems, such as a lack of parking spaces and illegal parking on public roads, especially in the city centers (Ishioka, 1992).

In addition, drivers and facility managers/workers of MSUP responded that there was inadequate parking lot in the area and there were high demand for car parking before the construction of the MSUP facility. The area has many functions that attract the public within the range of the Meskel Square. So, the area needs adequate parking lot to accommodate the demand. As study estimation shows that 14% of traffic density is created by searching for parking space and 50% of increase in congestion-related time loss on roads has been generated due to shortage of parking space (Brooke, 2015). As Wang., et al 2014, states the social, economic, and environmental impacts of traffic congestion have been enormous in recent years considerable. The construction of underground parking facilities has increasingly drawn attention as a solution for parking problems in urban areas (Ishioka, 1992). Thus, lack of parking lot is a major cause of traffic congestion in urban areas; therefore, the construction of the MSUP facility solved parking lot shortage by providing smart parking service to its customer.

Furthermore, Meskel square street junction being the center of the city and having six approaches, it is unique in its nature compared with other junctions. The six approach streets to Meskel Square area are Bole, Megenagna, Main Palace, Arada, Mexico, and Akaki. Based on data obtained from of drivers and facility managers/workers majority of them responded that there was slow traffic and congestion in all approach streets before the construction of facility, the problem was observed mainly during peak hours. In addition, respondents chose the other uses of the square (sporting activity, parking lot, bus terminal, and other functions) and on street parking, especially during the peak hours were the other main causes of traffic flow problem and congestion in the approaches. However, traffic flow and congestion improved noticeably after the construction of the facility and the renovation of the area. After the construction of the facility there is no parking space shortage in the area, though still drivers are parking their cars illegally in the area. So, drivers must be encouraged to park their cars in the facility.

According to drivers and facility managers/workers, from Monday to Friday and during the morning hour's traffic flow was slow and congested in the area, One of the main problems in Dare Salaam, Tanzania was congestion, especially in the evening and in the morning (Robert and Kiunsi, 2013). According to Fasika, 2015, the increase in traffic congestion on many streets and highways was the main concern of tourists, administrators, trade developers and the community at large. Similarly, Wang., et al 2014, highlights the social, economic, and environmental impacts of traffic congestion have been enormous in recent years considerable.

The majority of the drivers parked their car in the facility during weekdays for work purposes, and because there is no adequate car parking lot in the area. Getting parking facilities simply is the highest problem and difficult which leads the drivers spend more time for searching the vacant parking spots as it is shown in reality situation (Chaniotakis, 2014). The Meskel Square area is a centre for work, business and different commercial activities, attracting a large number of customers for different purposes including shopping and entertainment purposes.

4.3.2 Adequacy and efficiency of MSUP facility and satisfaction of drivers

According to drivers and facility managers/workers, the facility has adequate number of car parking spaces and provides efficient parking service to its customers in the area.

Parking is one of the comprehensive components in land use appearing in residential, shopping and industrial areas, and is related to all kinds of trips occurring in traveling, shopping and leisure trips (Mersden, 2006). In addition, the city administration needs to take additional measures to improve traffic flow and congestion in the area so that the area becomes a commercial hub of the city. Parking challenges in the capital will continue to be a major problem due to poor parking policies, poor city planning, population growth, and overcrowding (Bundara, 2010).

Therefore, underground parking can be used as a solution to parking problem in different areas where there is parking lot shortages. The construction of the MSUP facility and world underground development experiences clearly showed that urban underground spaces has potential for future infrastructure development and utilization in the city.

CHAPTER FIVE

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Currently, Addis Ababa is suffering from a serious traffic flow problem which is mainly caused by shortage of parking lots in the city. Meskel Square is located at the center of Addis Ababa; the area was experiencing serious traffic flow and congestion problems before the construction of the MSUP facility. Lacks of parking lots in the area were the main cause of congestion in the area. Questionnaire and interview were used to evaluate traffic flow conditions and availability of adequate parking lot in the area before and after the construction of the MSUP facility and also evaluated the adequacy and efficiency of the facility.

Driver's questionnaire and manager's/workers interview results clearly showed that traffic flow was slow and congested in the area before the construction of the facility. Shortage of parking lots in the area was the main causes of the problem. Furthermore, the result clearly showed that traffic flow and congestion has improved after the construction the facility. The construction of the MSUP facility and the renovation of the area were the main reasons for the traffic flow improvement in the area. Concerning about the adequacy and efficiency of the facility, all drivers and facility managers/workers agreed that the facility is adequate to accommodate parking demand in the area and is providing efficient parking service to its customers.

Hence, the analysis result clarified the MSUP facility has played big role to improve traffic flow problem and congestion in the area.

5.2 Recommendations

Based on the analysis result found from questionnaire and interview on traffic flow conditions and availability of adequate parking lot in the area before and after the construction of the MSUP facility and the adequacy and efficiency of the MSUP facility the following points are recommended to improve traffic flow and congestion in the Meskel Square area and to increase the efficiency of the facility.

- The MSUP facility is working below its capacity due to many reasons, first, it is new to its customers by being underground and fearing large amount of fee, second drivers are still parking their cars illegally in the area; so the facility management must advertise the facility to create awareness about the facility and increase its customers. In addition, the facility management must work with the law and enforcement bodies to prevent illegal parking in the area.
- Even though all drivers agreed that the facility provides an excellent service to its customers, it has some accessibility problems. Drivers complained that lack of parking signs that guide them where the MSUP facility entrance from the streets is, and also while leaving the facility drivers need to drive to Bole direction even if they want to drive to another direction. Therefore, the facility should place appropriate parking entrance signs on appropriate place, so that drivers can see it clearly enter and leave the facility without any confusion and causing an accident.
- The other concerns of drivers were security check at the entrance of the facility. According to drivers, security checks at the entrance takes a longer time and are frustrating, so the management must try to replace its manual security check with modern x-ray machines to reduce security checking time and avoid frustration of customers.
- The MSUP facility has been developed to relieve traffic flow problems and congestion in the Meskel Square area. The majority of the urban underground space utilization in Addis Ababa is building basements built below commercial and residential buildings, and for the installation of utility services at a shallow depth. Thus, the result obtained from this study will raise policy maker's awareness on the utilization of urban underground space in the future.
- Therefore, the result obtained from this research encourages future utilization of underground parking, and other urban underground infrastructures in different areas of the city and country.

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ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY SCHOOL OF CIVIL ENGINEERING & ARTHITECTURE DEPARTMENT OF URBAN PLANNING AND DESIGN MSC PROGRAM

Dear Respondents, thank you in advance for your unreserved cooperation. The purpose of this study is to obtain information about **'' The Role of Addis Ababa Meskel Square Underground Parking (MSUP) on Traffic Flow''** as a requirement in partial fulfillment of the award of Masters Degree in Urban Planning and Design from Adama Science and Technology University. Your voluntarily participation in responding the survey questions with accurate answer is vital to complete the research successfully. All information you provide will be used for only the academicals purpose and will be kept confidential.

Fikadu Alemu

Phone number: +251-911-607115 and

Email: falkas95@gmail.com or fak95@yahoo.com

APPENDIX A

Part I Traffic flow in the area of Meskel Square Underground Parking **(MSUP)**

Section 1 Biographical details of ***drivers***

Demographic variables	**Tick your choice**(√)							
Gender	Male		Female					
Age in years	18-30		31-40		41-50		50+	
Educational background	Certificate		BA/BSC		PhD			
	Diploma		MA/MSC		Other specify			
Job Position	Manager		Engineer		Forman			
Experience In years	1- 5		5 - 10		10 -15		15	

Section 2 Questionnaire of ***traffic flow*** in the Addis Ababa Meskel Square area and the ***adequacy*** and ***efficiency*** of MSUP facility for professionals ***Drivers***

A. Traffic Flow for professionals *Drivers.* Tick your choice(√)

1. Are there adequate parking lots in the area of Meskel Square before the construction of MSUP facility?

   ☐ Yes ☐ No

2. If your answer for question No. 1 is 'Yes', do you think parking lot shortage affected traffic flow and caused traffic congestion in the area?

   ☐ Yes ☐ No

3. If your answer for question No. 2 is 'Yes', what were the main causes of slow traffic and congestion in the area? Tick one or more of your choices.

   ☐ Shortage of parking lot ☐ narrow street carriage
   ☐ On street parking ☐ other uses of the square
   ☐ Poor traffic management ☐ pedestrians

Others_____

4. Which approach had slow traffic and more congestion before MSUP facility and which approach improved traffic flow and congestion after the construction of MSUP facility?

Approach leg		**Before,** approach had slow traffic and more congestion	**After,** approach improved after the construction of MSUP facility
Bole airport approach	Yes		
	No		
Megenagna approach	Yes		
	No		
Main Palace approach	Yes		
	No		
Arada approach	Yes		
	No		
Mexico approach	Yes		
	No		
Akaki approach	Yes		
	No		

5. If your answer for question No. 2 is 'Yes', at what time slow traffic and congestion was mainly observed?

	Morning	**Afternoon**	**Evening**	**Night**
Monday to Friday				
Saturday				
Sunday				

6. If your answer to question No. 4 is 'Yes', to all approaches what are the main reasons for traffic flow improvement in the area?

☐ The construction of MSUP ☐ Widening of streets in the area

☐ Better traffic management ☐ Avoiding other uses of the square

☐ Renovation of the Meskel Square ☐ Better pedestrian's lane in the area

Others_____

7. Which of the following best describes why you are parking your car on the Addis Ababa MSUP facility? Tick one or more of your choices.

☐ Work ☐ Business ☐ no other parking in the area

☐ Entertainment ☐ Shopping ☐ Visiting family/ friends

☐ Drop /load passengers

Others_____

8. Express the frequency of your parking in the MSUP? Tick one or more of your choices.

☐ Once a day ☐ More than once a day ☐ not often

☐ Weekend's only ☐ Weekdays only ☐ Everyday

9. Is the MSUP facility service is adequate and efficient?

☐ Yes ☐ No

10. Are you happy with the current parking service of MSUP facility?

☐ Yes ☐ No

Section 3 Interview Questions for Addis Ababa MSUP facility managers/workers

Please state your name and position in this organization

Name _____ Position_____

1. Are there high demands for parking lot in the area of Meskel Square before the construction of the MSUP facility?

_____

_____

2. Are there adequate parking lots in the Meskel Square area before the construction of the MSUP facility?

_____

_____

3. Do you think shortage of parking lots before the construction of MSUP affected traffic flow in the area?

_____

_____

4. What were the main causes of traffic congestion in the area of Meskel Square before the construction of the MSUP facility?

_____

_____Are there adequate and efficient parking spaces within the MSUP facility that can accommodate current parking demand in the area?

_____

_____

5. Which approach leg to the Meskel square was more congested before the construction of the MSUP facility?

_____

_____

6. Do you think traffic flow has improved in the area of Addis Ababa Meskel Square after the construction of the MSUP?

_____

_____

7. What are the main reasons for the improvement of traffic flow and congestion in the area?

_____

_____

8. Do you think vehicles driving in and out of MSUP facility create congestion in the area? Is it easily accessible?

_____

_____