



**ADDIS ABABA UNIVERSITY**

**INSTITUTE OF TECHNOLOGY**

**SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING**

**ASSESSING SOCIO-ECONOMIC IMPACT OF ROAD TRAFFIC CONGESTION IN**

**ADDIS ABABA CITY IN CASE OF MEGENAGNA TO CMC MICHAEL ROAD  
SEGMENT**

**By**

**SILESHI SETITO SITOTAW**

A thesis submitted to the School of Graduate Studies of Addis Ababa University in Partial fulfillment of the Degree of Masters of Science in Civil Engineering under Road and Transport Engineering.

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**Addis Ababa**

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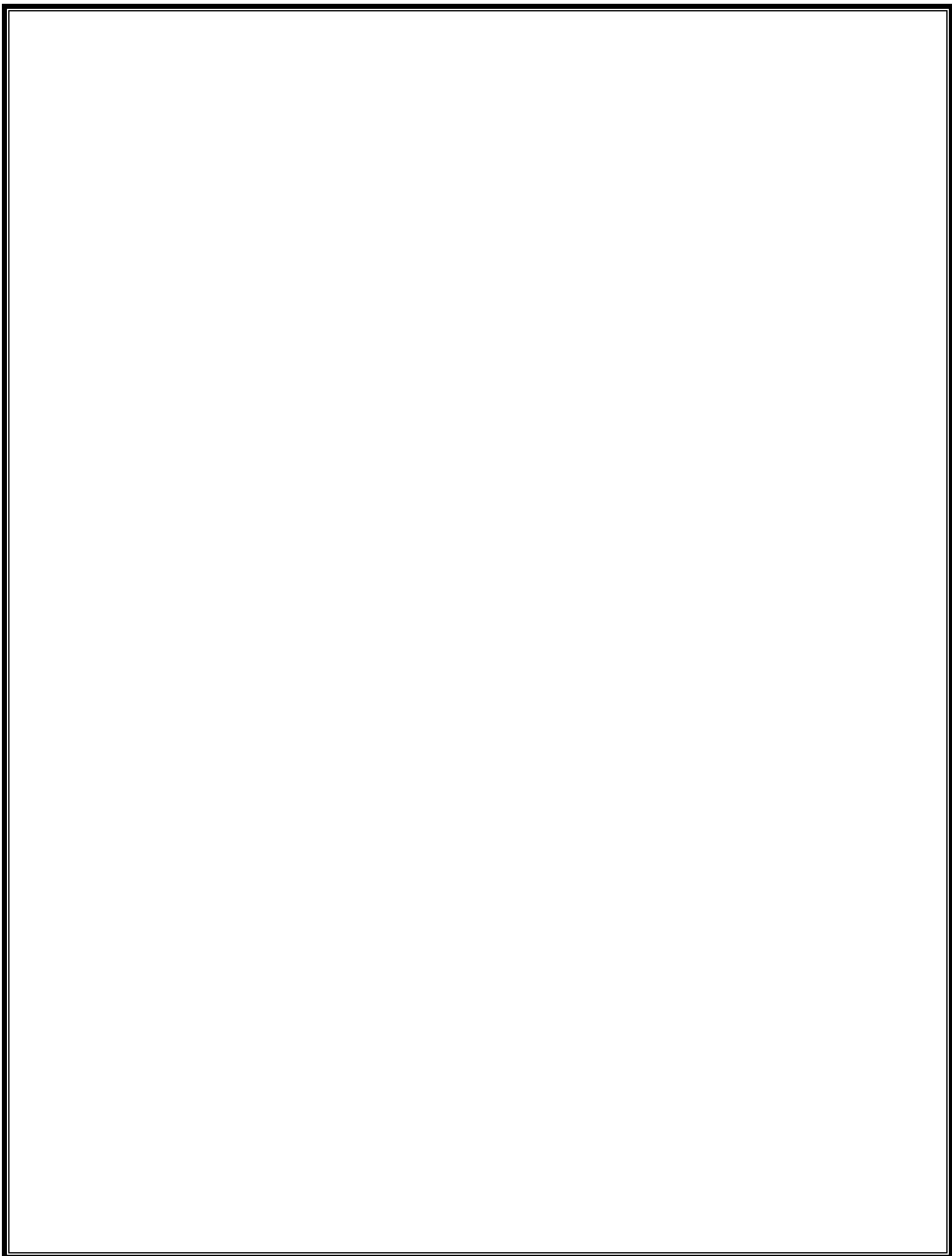
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**Declaration**

I certify that this research work titled “ Assesing socio-economic impact of road traffic congestion in case of Megenagna to CMC Michael road segment, Ethiopia.” Is my work. The work has not presented elsewhere for assessment and award of any degree.

Sileshi Setito Sitotaw

Signature.....

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### ***Abstract***

*As modernization and consequently the urbanization moves forward, the use of motorized transport to maintain the socio-economic and physical integration of city increases. The rise in automobile ownership although not yet very significant together with the poor condition of the roads and the poorly functioning traffic system have resulted in high level of congestion particularly at peak hours, where by the probability of occurrence of congestion is very high. Traffic congestion has various negative impacts ranging from economic loss to adverse environmental and social impacts ranging from economic loss to adverse environmental and social impacts. Generally, transport in Addis Ababa is chaotic, inefficient, unreliable and dangerous. The study focuses on the socio-economic impact of road traffic congestion in Addis Ababa city in case of Megenagna to CMC Michael road segment. The state of the objective analysis of delay, impact of congestion and the total economic cost of congestion were adapted of the methodology based on primary data collections. Which was collected by questioners distributed in to stake holders and traffic volume and travel time were recorded in the field using video recording and its adapted descriptive statistics and analysis by using Statistical Package for Social Sciences (SPSS). Based on the analysis of the result the mean variance significant at 0.05 ( $P\text{-value} < 0.05$ ) so that, road traffic congestion is the impact of socio-economic activities. The average travel speed of the vehicle during the morning and night time is 10.6 Km/hr. But during mid-day the average travel speed is 22.6 km/hr it increased relative to the peak period and still, it is congested. The total average of the speed of vehicles through the segment is 16.6 km/hr. The total time losses in the year are 3850.59 hrs. The total economic cost of congestion had been analysis based on speed-flow curve procedures. So that, the total economic cost of congestion in ETB 42,897752.15.*

*Key words: Traffic congestion, impact of congestion, Total Economic cost of Travel Time congestion*

## List of Abbreviation

ANOVA	-	Analysis of variance
Avoc	-	Average vehicle occupancy
CEBR	-	Centre for Economics and Business Research (CEBR)
TTI	-	Travel Time Index
CSA	-	Central statistics Agency
CSU	-	Civil service University
ETB	-	Ethiopian birr
HCM	-	Highway capacity manual
HDR	-	Highway development research
LOS	-	Level of service
MS	-	Mean square
PCU	-	Passenger car unit
SPSS	-	Statistical Package for Social Sciences
SS	-	Sum square
VOT	-	Value of time
V/C	-	Volume to capacity ratio
VTTS	-	Value of Travel Time Saving
VTT	-	Value of Travel Time

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## CHAPTER ONE

### 1 Introduction

Movements of people, goods and information have always been fundamental components of human societies especially the urban centers have become increasingly dependent on their transport systems to support a wide variety of activities ranging, among others, from commuting, supplying energy needs, to distributing parts between manufacturing facilities and distribution centers. In other words, the productivity of urban centers is highly dependent on the efficiency of transport systems to move people and goods between multiple origins and destinations [1,2]

Traffic congestion continues to remain a major problem in most cities around the world, especially in developing regions resulting in massive delays, increased fuel wastage and monetary losses. Due to the poorly planned road networks, illegal use of roads a common outcome in many developing regions is the presence of small critical areas which are common hot-spots for congestion; poor traffic management around these hotspots potentially results in elongated traffic jams. [3] Road traffic congestion, according to Goodwin, P. B. (1997) can be defined as the impedance vehicles impose on each other, due to the speed-flow relationship, in conditions where the use of a transport system approaches its capacity. Accordingly to Banjo, G.A. (1984) also defined congestion as the saturation of road network capacity due to regular and irregular reductions in service quality exemplified by increased travel times, variation in travel times and interrupted travel.[4,5,6]

According to urban mobility report (2009), overall, it is difficult to overstate the negative effect that congestion has on the nation's economy. In 2007 estimates, congestion result in 4.2 billion hours of wasted time for commuters. In 2013 traffic congestion cost Americans \$124 billion in direct and indirect losses, this number will rise to \$186 billion in 2030 [7].

The transportation with its branches, that is, the public and the private sectors, is one of the most important components of the development of a country. It is a concern all around the world and is supposed to cope with the rural and urban development. Traffic congestion however, is more the outcome of a basic mobility problem, which is that too many people want to move at the

same time each day. For example, efficient operation of the entire society system requires people go to work, go to school and even run errands about the same hours and interact with each other. The problem of congestion exists in every major metropolitan area in the world. Peak-hour traffic congestion in almost all large and growing metropolitan regions around the world is here to stay. In fact, it is likely to get worse during the next few decades mainly because of rising population and wealth.[8]

As modernization and consequently the urbanization moves forward, the use of motorized transport to maintain the socio-economic and physical integration of city increases. The rise in automobile ownership although not yet very significant together with the poor condition of the roads and the poorly functioning traffic system have resulted in high level of congestion particularly at peak hours, where by the probability of occurrence of congestion is very high. Addis Ababa city transport authority report depicts, the vehicle fleet in 2016/17 is estimated to be 524,444 with the average growth of the vehicle increase 30 percent in the year.[9]

Social impact refers to the effect of an activity on the social fabric of the community and well-being of the individuals and family. In business and government policy, social impact refers to how the organization's actions affect the surrounding community. Social impacts can link to areas such as health and community. The term social problem means a social situation caused by repetitive patterns of social behavior that result in negative consequences and fall short of the affected society's normative ideal.[10] Traffic congestion has various negative impacts ranging from economic loss to adverse environmental and social impacts. Because the roads are free of charge, there will be no financial incentive that would stop drivers from overusing the roads until the point where the road begins to collapse through continuous congestion [10]. By doing so, each driver incurs a private and public cost when they drive. The private cost includes the journey time and fuel used where as the public cost includes the "Cost imposed to the community in the form of noise, accident risk, fumes, etc." [10,11] Both of these costs will increase with the increase of traffic congestion. Drivers waste more time and fuel if they are stuck in a traffic jam. The objective of this paper to analysis the socio-economic impact of road traffic congestion and indicate the core of the problem in Addis Ababa city.

## 1.1 Statement of the Problem

Urban road traffic congestion is currently severe in most cities in the world due to economic and social development. Prevalently, Ethiopia is one of the countries that are in rapid economic development and as its effect of road traffic congestion in the city is visible on the socio-economy, infrastructures, environment and health. It's associate with increase vehicular queuing and poor accessibility to work and home places especially in the morning and evening hours. The serious road traffic congestions are observable in times when most workers are going to their work places and workers go back to their home places. Despite the intensive road network expansion in Addis Ababa, road traffic congestion, long queues and excessive delay during peak hours at junctions and bottleneck road have been major problems in the city. Generally, transport in Addis Ababa is chaotic, inefficient, unreliable and dangerous. It is negatively affects the society especially the urban poor through loss of productivity, inhibiting human development and reducing the quality of life, change in accident frequency and characteristics, increase in air pollutants and emissions, increased vehicle operating costs and increased noise nuisance, increase wastage of time, increase delay, lack of comfort. All these complications and problems which most of employees and the people of the general public do encounter under different degrees and circumstances are said to be directly associated with the existing road traffic congestion. Accordingly, the above problem, the objective of this thesis is to assessing the socio-economic impact of road traffic congestion in Addis Ababa city in case of Megenagna to CMC Michael road segment.

## **1.2 Objective of the Study**

### **1.2.1 General Objective**

The general objective of this thesis is assessing socio-economic impact of road traffic congestion in Addis Ababa city in case of Megenanga to CMC Michael road segment.

### **1.2.2 Specific Objective**

- To analysis delay due to road traffic congestion.
- To assess the socio-economic effects of traffic congestion on the communities of living in the city.
- To estimate the total economic cost of congestion in the road segment by considering only vehicle delay using travel time approach.

## **1.3 Research Question**

- How to measure and analysis of traffic delay?
- Is congestion impact on socio-economic activities?
- How much waste economic costs of travel time by congestion?

## **1.4 Significance of the Research**

Now a days road traffic congestion has a serious effect on socio-economic impact of once country development so, without a doubt the research on socio-economic impact of road traffic congestion has a wide range of significance for both the researcher and city administer. The researcher will have a better understanding regarding the determination of congestion. The road traffic congestion measures analysis shows the existing situations and using these result; we can predict what will happen in the future, due to the fact that every person living working or even who made a visit within the city is affected or touched differently by the existing road traffic congestions, leaving aside its general impact on peoples' socio-economic impact in the city. It has expecting to show how the traffic congestion has affected the residents of Addis Ababa city socially and economically. The research provided relevant recommendations and suggestions in accordance to the nature of the findings as well as relating it to the current national transportation policy. Also, the research pin pointed some areas which require future investigation in the future on condition that there will be a gap between it and other studies on the problem. Finally, the

study will help the researcher to fulfill the partial requirement for being awarded the degree of Master of Science in Road and transport engineering at Addis Ababa University.

### **1.5 Scope of the Study**

This study is conducted to assess the socio-economic impact of road traffic congestion in Addis Ababa city in case of Megenagna to CMC Michael road segment (travel time cost or delay cost). It is almost all socio-political and economic sectors being public, private and international. Due to this case, it has a great number of employers and employees both from formal and informal sectors; being private, public or international. The people under different people depend on the private and public transport. This shows that they are directly linked with the road traffic congestion. As generally, this thesis was conducted assessing the socio-economic impact of road traffic congestion in the case of Megenagna to CMC Michael road segment. The specific objective is focus only analysis of delay; socio-economic effects of traffic congestion on the communities and estimate the total economic cost of congestion ( the congestion cost is focus only travel time delay but not include vehicle fuel cost, accident cost and environmental cost due to insufficient of data).

### **1.6 Limitation of the Study**

The limitation of the research of the study carried out the following:

- The research is carried out only for the Megenagna to CMC Michael urban street roads due to heterogeneous of traffic flow, road condition of and driving characteristics, insufficient of secondary data of vehicle volume.
- The proposal writer, researcher faced a number of challenges like the necessary data, tools of data collection, Unavailability of data resources.
- During the questionnaires, many of the people who were initially approached to answer questions were not comfortable and therefore not cooperative. Due to the nature of the traffic congestion, many of the passengers were very tired, exhausted and sometimes angry and disappointed. It was therefore not an easy task convincing them to answer the

questions. Some of the respondents refused to answer the questions and as such were replaced.

### **1.7 Expected benefits of the study**

After the completion of this thesis the major expected beneficiaries of the finding of this study will be:

- To reduce the socio-economic impact of road traffic congestion in the city
- Deliver predictable travel times.
- To build effective traffic signals and intelligent traffic management in the city.
- To expand the road network based on the mobility of number of vehicles in the city.
- Manage highly traffic road ways to preserve adequate system performance.
- To create or design effective prevention and protection policy, strategy to policy makers, transport authorities, road engineers, and other concerned bodies, to take counter measures and monitor road traffic congestion.

### **1.8 Conceptual Framework**

A conceptual frame work can be defined as a set of broad ideas and principles taken from relevant fields of enquiry and used to structure a subsequent presentation. It is a research tool intended to assist a researcher to develop awareness and understanding of the situation under scrutiny and to communicate. It forms part of the agenda for negotiation to be scrutinized and tested, reviewed and reformed as a result of investigation.

The critical and comprehensive reading made and analysis of various literature works shows that there is direct relationship between traffic road congestion and various socio-economic activities. The independent variable road traffic congestion affects the dependent variable employee's people's well-being in various ways delays, wastage of time, health and environmental problem, inability to forecast travel time, wasted fuel, extra transport cost, increase vehicle operating cost, psychological and academic effect on community etc.) This in turn affects social economic activities. A slight change in independent variable leads to the same changes in dependent variable. Thus the dependent variable employees or people social-economic activities are influenced by the independent variable road traffic congestion. This affirmation made above on

the relationship between the two variables can be more understood by taking consideration of the diagram below.

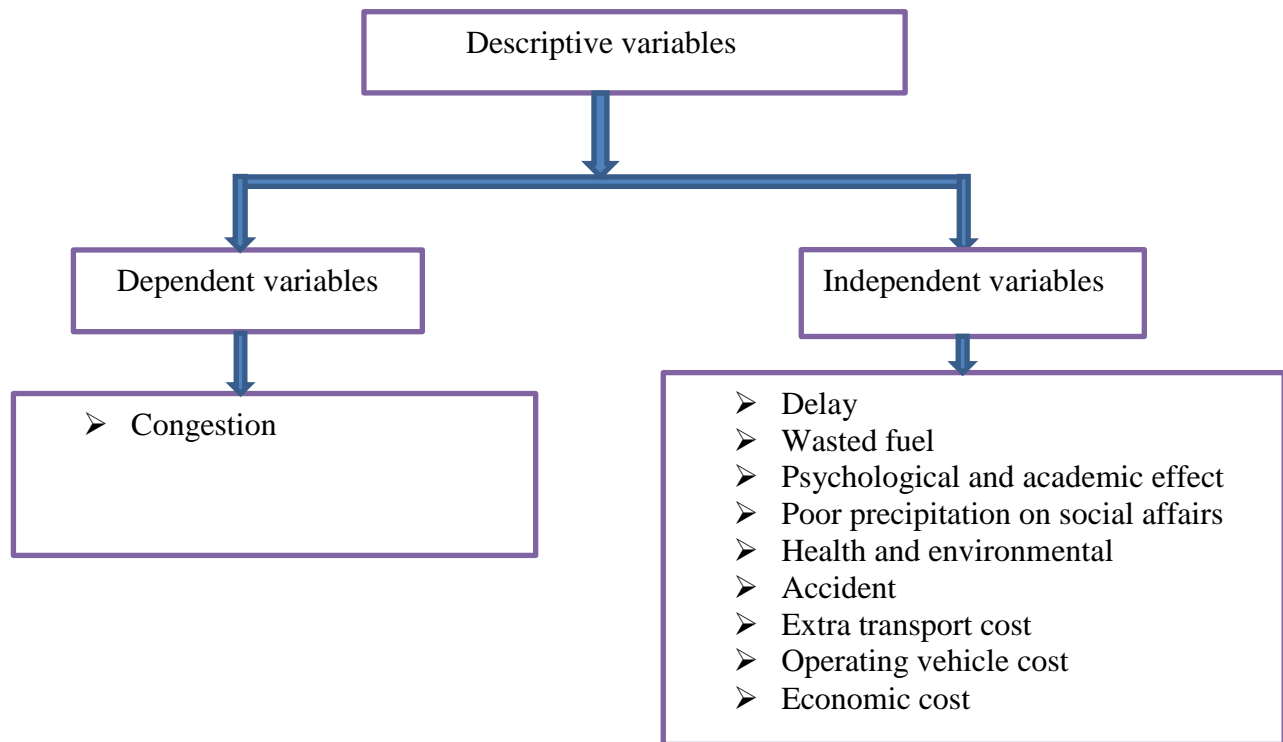


Fig.1. 1 Conceptual frame work (source own)

## 1.9 Organization of thesis

The overall this thesis organized under five chapters as follows: Introduction, Literature review, methodology, Analysis of the result and conclusion and recommendation.

Chapter one: Gives brief introduction of thesis, state the research problems, define research objectives and question related to the objectives, performed hypothesis test, significant of the thesis, scope of the study, limitation of the study, expected benefits of the study and conceptual frame work of descriptions of variables selected for analysis etc.

Chapter two: Briefly review literature on descriptive analysis of related literature review.

Chapter three: Methodology and description of study area, research design, sample size determination and method of data collection.

Chapter four: To analysis the result and discussion

Chapter five: To conclude and recommendation based on the research objective.

## CHAPTER TWO

### 2 LITERATURE REVIEW

#### 2.1 Introduction

One of the significance is the traffic congestion issue as a global phenomenon in the management of capital cities, giving the level of population and activity concentration. United Nations first reported the urban population dominance in 2010, revealing that urban areas are home to 3.5 billion (50.5percent) of world's population and cities population is expected to increase to 5.2 billion in 2050 [12] Thus, a review of various theories and empirical literature relevant to the assessment on the socio-economic impact of road traffic congestion in Addis Ababa city in case of megenagna to CMC road segment was done relevantly to the conceptual frame work presented. A theoretical framework is the conceptual model of how theories make logical sense of the relationship between the several variables that have been identified as important to the problem. It can be viewed as both a foundation and a pillar of a research project. Therefore, theories aid a researcher in understanding the problem and guiding the study.

The capital city of Addis Ababa is both a focus for urban bus and taxi operations and for urban goods only brief references have been made to urban transport development in other cities in Ethiopia. Transportation is also diverse. It is multi-sector and, as such, it needs to be fully integrated with other municipal sectors. New transport infrastructure must be part of a balanced urban development program including traffic demand management, public transport provision and supporting land use policies.

Economically, transport is an essential element of city development that, in turn, is a major source of national economic growth. Simply stated, poor transport inhibits growth. Furthermore, socially, transport is the means of accessibility to jobs, health education and social services essential to the welfare of the city residents. Deteriorating transport conditions affect all city residents; they impact particularly the poor through a decline in public transport service levels, increased length of the journey to work and other essential services and the negative impacts on environment, safety and security that the poor are least able to mitigate.[13]

## 2.2 Definition of Traffic Congestion

Traffic congestion is a condition on any network as vehicle use increases and is characterized by slower speeds, longer trip times, and increased queuing. The most common example is for the physical use of roads by vehicles. When traffic demand is greater enough that the interaction between vehicles slows the speed of traffic stream, congestion is incurred. As demand approaches the capacity of a road, extreme traffic congestion occurs. When vehicles are fully stopped for periods of time, this is colloquially known as traffic jam [14].

Congestion is essentially a relative phenomenon that is linked to the difference between the road way system performances that users expect and how the system performs. Traffic congestion is a condition on road networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increased vehicular queuing. The most common example is the physical use of roads by vehicles. When traffic demands exceeds or is greater enough that the interaction between vehicles slows the speed of traffic stream, it results in some congestion. As demand approaches the capacity of a road (or the intersections along the road), extreme traffic congestion sets in. When vehicles are fully stopped for periods of time, it is colloquially known as a traffic jam or traffic snarly - up. In other words, congestion can be seen as a situation in which demand for forward space exceeds supply.

Traffic congestion is imprecise and is made more difficult since people have different perceptions and expectations of how the system should perform based on whether they are in rural or urban areas, in peak or off peak, and as a result of the history of an area.[15] Traffic congestion is a widely recognized transport cost. It is a significant factor in transport system performance evaluation and affects transport planning decisions. As a road reaches its capacity, each additional vehicle imposes more total delay on others than they bear, resulting in economically excessive traffic volumes. Congestion tends to increase travel time, arrival unreliability, fuel consumption, pollution emissions and driver stress, and reduce life satisfaction. [16]

Urban traffic congestion must be understood in the wider context of city dynamics and agglomeration benefits. Traffic congestion in the urban area is often the outcome of successful urban economic development, employment; housing and cultural policies that make people want to live and work relatively close to each other and attract firms to benefit from the gains in productivity derived. There are many indications that even though they may not be thrilled by the

prospect, urban road users are prepared to live with crowded roads so long as they derive other benefits from living and working in the cities.

Time may be one of the most important factors to determine whether a transport system is efficient or otherwise. If the ratio between time taken by private car and time taken by public transport is less than one, the private transport would be more efficient.

### **2.2.1 Types of congestion**

Broadly speaking, there are two forms of congestion: recurrent congestion and non-recurrent congestion.

Recurrent congestion is generally the consequence of factors that act regularly or periodically on the transportation system, such as daily commuting or weekend trips. However, even recurrent congestion can display a large degree of randomness, especially in its duration and severity.

Recurrent congestion occurs mainly when there are too many vehicles wanting to use the road at the same time. Recurrent congestion typically occurs during weekday morning and afternoon peak periods, when most people go to work and return home at around the same time.

Non-recurrent congestion is occurs at non-regular times at a site. It is unexpected and unpredictable by the road users and is normally due to accidents, vehicle breakdowns or other unforeseen loss of carriageway capacity. Non-recurrent congestion is associated with random conditions or special and unique events, such as traffic incidents (disabled vehicles), truck spills, accidents, work zones, unusual or disruptive maneuvers by individual drivers, irregular facility of maintenance operations (e.g., seasonal street cleaners), adverse weather and special events. Because of the random nature of this type of congestion, non-recurrent congestion is more difficult to predict and address. The impact of non-recurrent congestion is significant, in that the reliability and predictability of travel time is of utmost importance to the public, to the goods generating industries and to the economy in general.

### **2.2.2 The Causes of Traffic Road Congestion**

The main cause of road traffic congestion is that the volume of traffic is too close to the maximum capacity of a road or network. Congestion in the UK is worse than many, perhaps most, other European countries. The main factors leading to these situations include: rapid expansion of the city which has far outpaced the capacity to provide basic infrastructure (such as good roads) and services, poor state of majority of the buses, untrained bus drivers and conductors driven by the pursuit of daily revenue targets payable to the bus owners, non-adherence to traffic rules and regulations; and lack of an organized public transport system. [17] According to Downie also opines that traffic congestion occurs when the volume of vehicular traffic is greater than the available road capacity, a point commonly referred to as saturation. He describes a number of specific circumstances which cause or aggravate congestion. [18] Most of such circumstances are concerned with reduction in the capacity of road at a given point or over a certain length, or increase in the number of vehicles required for the movement of people and goods. He argues that economic surge in various economies has resulted in a massive increase in the number of vehicles that overwhelms transport infrastructure, thus causing congestion on roads in cities.

#### **2.2.2.1 Traffic Influencing Events**

External events have major impact on traffic flow. These included traffic incidents such as crashes and vehicles breakdown; work zones, bad weather such as heavy rainfall; special events like passing of government officials; and poorly timed traffic signals. When these events occur, their main impact is to steal physical capacity from the road way. Such events cause travelers to think their trips. The level of congestion on a road way is determined by the interaction of physical capacity with the events that are taking place at a given time.[10]

#### **2.2.2.2 Population Increase and Vehicle Ownership**

Population increase is one of the causes of traffic congestion in the world. It is the process that leads to spatial concentration of households and economic activities within an interrelated network of markets in a limited area. Increases in population in urban areas are caused by push and pull factors [10,19]. More than one-half of the world's population lives in the cities. The

growth of population in urban globally averages 2 percent annually and the number of megacities-those with population in excess of 10 million people-has quadrupled in the past two decades. These trends are expected to continue being dominated by demographic shifts in the developing world. The United Nation predicts that more than 80 percent of population growth in the next ten years will occur in the developing countries urban areas. However, many people in towns and cities and specifically in Addis Ababa own vehicles. Number of vehicles increase disproportionally with the road capacity and this leads to traffic congestion. As population continues to increase and as the city continues to sprawl, more people live and work in the city and make more trips within the urban areas, often over long distances. Consequently, the limited capacity of the existing transport infrastructure is stretched to the limit. Thus, it has become a constraint to cope with the public demand for travel. The performance of public transportation in the city in social, economic and environmental aspects is thus distressing [10,17]

### **2.2.2.3 Insufficient Road Width**

Most of roads are narrow compared to the volume of traffic in the road. This problem affects megenagna to CMC roads including roads extending to the including roads extending to the periphery. An example is Megenagna to CMC road in Addis Ababa city, which is narrow and has no parking bays; Illegal traders different goods exchange on road; construction materials used on the road; a situation which forces the vehicles to stop anywhere on the road for passengers to board and offload. This practice causes more traffic congestion and more chances for accidents. According to Shanko carried out a study on segmental assessment of levels of traffic jam the findings show that the effect of motor vehicles when the location is bottleneck is at the top of the upgrade than when bottleneck is at the bottom of upgrade. Further the study found that the effects of heavy vehicle increases with increase in grade percentage of congested traffic stream.[10,17]

According to Tulu Segni Getu reviewed that generally sharp curves result high accident rate than more gentle curves, especially below 20 m radius rate of accident is increasing. Almost, all previous studies' conclusions indicate that rate of accident is high on horizontal curves, at intersection and bridges.[20]

#### **2.2.2.4 Inadequate Parking Space and Wrong Parking in the City Centre**

Most cities particularly in developing countries do not have adequate parking areas; a situation which accounts for haphazardly parking along the roads. In Addis Ababa city in case of megenagna to CMC road segment, the most serious problem related to parking can be vividly seen at the city center. It is aggravated by the nature of the city where the major roads converge in the city center, hence forcing all vehicles in the city streets. This is not only the problem of the segment of Megenagna to CMC road segment, but also the whole Addis Ababa city. This occurs because whenever one tries to park somewhere they slow their vehicles causing those following him/ her to slow down too and increase traffic congestion. This behavior or situation is common in the city of Addis Ababa city.[10]

#### **2.2.2.5 Poor Traffic Management**

The poor traffic management is a result of malfunctioning of traffic lights, absence of road signs, inadequate enforcement of laws (e.g illegal trade, construction works, etc.), low penalties given to punish violators of traffic congestions, employment of few law enforcers for instance traffic police and lack of facilities to tow disable vehicles on the road. This is also a problem in other developing countries whose economy is weak. As a result, they cannot afford to control traffic using modern technology which is rather expensive in terms of resources. Effective traffic management and control system is key to ensuring effective transportation system in the urban areas. This involves management and control of road signals, road space, parking space and road users. [21,22, 23,24]

#### **2.2.2.6 Drivers Misbehavior**

Addis Ababa is one of the cities which are highly characterized by reckless driving due to violation of traffic rules. Drivers have a tendency to disregard or violate the traffic regulations such as to overtake where it is prohibited, driving while drunk, neglecting road signs and markings, discharging passengers on the road instead of the bus to stop and the use of the U-turn where is prohibited. Drivers may lack confidence or ability due to poor training as well as lack of competencies. Thus, misbehavior of some drivers on failure to adhere to traffic regulations is among the main contributing factors to the increase of traffic jam.[10] There have been penalties (fines) for every fault made in order to discourage these misbehaviors, but it has not proved very

successful. Most of the drivers' malpractices in Addis Ababa city in case of megenagna to CMC increase the problem of traffic congestion and accidents. However, unethical practices by drivers are common to many countries including Ethiopia. When drivers are caught by police, the unethical police may release them through acceptance of bribes. The situations are also experienced most of in the city where the commuter minibuses and taxi are violates traffic regulations and therefore cause traffic congestion and accidents.

### **2.3 Theory of Social Development**

Social development can be summarily described as the process of organizing human energies and activities at higher levels to achieve greater results. Social development theory attempts to explain qualitative changes in the structure and framework of society, which help the society to better realize its aims and objectives.

A society's progress is determined by its ability to grow and change. The organizations and structures that drive its workings directly affect its ability to function. A theory of social development examines the strengths and resources available within a society and how they are used to promote social development. Investments in road transport increase net social welfare only if the total social benefits exceed social costs. Thus, potential benefits of lower production costs and consumer prices, greater variety in product choice, faster delivery, and spin-off effects such as value-adding or employment in related economic sectors, due to improved accessibility should be higher than the total costs of investment, operation, maintenance, and external effects.[25,26]

According to Hardin G. cites by Elisonguo A.D theory of social development identifies the factors that influence the growth of a society and how those factors affect change. Growth occurs according to a process of change that brings out the inherent strengths and abilities of a society. These changes affect how a society functions and how it is structured. Social development can take place on political, social, economic or technological levels. However, a society's economic progress is a significant indicator of social development.[10,27]

Organizational change within a society is a key factor influencing its social development. An increased awareness of how a society's available resources can be better utilized provides the direction needed for effective organizational change to take place. Social development theory

points to how this greater awareness allows societies to harness and direct their strengths and resources towards more productive ends. The result is a more efficient and directed output that benefits the society as a whole or works to improve the social conditions within specific segments of the population.

Physical changes within the social development of a society are borne out of the accepted models of productivity and organization that sustain its current existence. Revised agricultural methods, newly formed public assistance programs and the use of alternative energy sources are examples of physical changes. Existing conditions may be unable to meet the needs of the people in terms of providing for their survival. Conditions may escalate to the point where the structures within the society begin to break down. Medicare, the social security retirement system and the stock market are examples of structures within a society. As a result, existing patterns of organization become ineffective and further aggravate developing problems. These conditions set the stage for change to occur.[10,26]

Social development theory links a society's level of social interaction to its ability to change and grow. The level of interaction points to the interconnections that exist between the different functional areas within its structure. An example of this would be how closely a manufacturer and a retailer work together to ensure the success of a product. Social development occurs when organizational structures begin to work together to achieve a common goal by redefining their objectives and the methods used to carry them out.

## **2.4 Economic theory**

According to Hardin G. and Jones M. and Collings S. cites by Elisonguo A.D Traffic congestion costs consist of incremental delay, vehicle operating costs (fuel and wear), pollution emissions and stress that result from interference among vehicles in the traffic stream, particularly as traffic volumes approach a road's capacity. Congestion cost analysis concentrates arising from interactions between multiple vehicles on a homogeneous road section, and bottleneck congestion. Congested roads can be seen as an example of the tragedy of the commons.[10,24,27] Because roads in most places are free at the point of usage, there is little financial incentive for drivers not to over-use them, up to the point where traffic collapses into a jam, when demand becomes limited by opportunity cost. Privatization of highways and road

pricing has both been proposed as measures that may reduce congestion through economic incentives and disincentives. Congestion can also happen due to non-recurring highway incidents, such as a crash or road works, which may reduce the road's capacity below normal levels. According to economist Anthony Downs and Stephen, F cites by Elisonguo A.D argues that rush hour traffic congestion is inevitable because of the benefits of having a relatively standard work day.[10,28,29] In a capitalist economy, goods can be allocated either by pricing (ability to pay) or by queuing (first-come first-serve); congestion is an example of the latter. Instead of the traditional solution of making the "pipe" large enough to accommodate the total demand for peak-hour vehicle travel (a supply-side solution), either by widening roadways or increasing "flow pressure" via automated highway systems, Downs advocates greater use of road pricing to reduce congestion (a demand-side solution, effectively rationing demand), in turn plowing the revenues generated, there from, into public transportation projects.

## 2.5 Impact of traffic congestion

Congestion causes increased costs for travelers and freight movement, loss of time, accidents, and psychological strain.[30] This is not simply congestion of transit vehicles during peak hours, congestion of pedestrian on sidewalks as well as congestion of bicycle. Congestion is neither a new phenomenon nor a role effect of automobile. "As soon as the increase of population is created a demand for wheeled traffic in Rome, the congestion became intolerable. One of Julius Caesar's first acts on seizing power was to ban wheeled traffic from the center of Rome during the day.... Just as motor car congestion now affects small towns as well as big ones, so the increase of animal-drawn vehicles impeded circulation everywhere. Hence Claudius extended Caesar's prohibition to the municipalities of Italy; and Marcus Aurelius, still later, applied it without regard to their municipal status to every town in the Empire"[30]

Traffic congestion has various negative impacts ranging from economic loss to adverse environmental and social impacts. Because the roads are free of charge, there will be no financial incentive that would stop drivers from overusing the roads until the point where the road begins to collapse through continuous congestion.[10] By doing so, each driver incurs a private and public cost when they drive. The private cost includes the journey time and fuel used, whereas the public cost includes the "cost imposed to the community in the form of noise, accident risk,

fumes, etc”.[11] Both of these costs will increase with the increase of traffic congestion. Drivers waste more time and fuel if they are stuck in a traffic jam. The wasted time is the “time that could be used productively and there is an economic cost attached to it which, although difficult to measure, can be significant” [11, 31]. Only in the United States the “annual economic burdens range from \$83 billion to \$124 billion” from traffic delay.[22] In addition, Traffic congestions make it difficult for emergency services to perform effectively. The socio-economic cost of traffic congestion comes in many forms, such as increased fuel consumption, increased operating cost (wear and tear of vehicles), time wastage, reduced income, health challenges, shrink market coverage/reduced work force productivity, among other[10,32,33,34] While some of the costs are directly borne by drivers (e.g. wear and tear of vehicles, wasted time and increased fuel consumption), other external costs (such as, lost time, higher costs of production, lower productivity, and wasted fuel impact the economy as a whole. Whereas, the increased pollution and greenhouse gas emissions that result from growing congestion affect everyone. Some of the impact of congestion is list below within explanation.

### **2.5.1 Increased travel time**

Travel time is one of the largest categories of transport costs, and time savings are often the greatest expected benefit of transport improvement projects. Factors such as traveler comfort and travel reliability can be quantified by adjusting travel time cost values.[35, 36]

Dachis, he mentioned various costs caused by traffic congestion, traffic slows down speed which is a visible cost and when people forgo their trips because of fear for congestion then it becomes a hidden cost of congestion and when traffic congestion make people not to be live in their cities they miss finding better jobs, and sharing better amenities. He again suggested that on top of the cost of congestion due to slower travel, these wider, hidden costs of congestion range between \$500million and \$1.2billion per year

The most prominent cost of traffic congestion is the delay associated with lower travel speeds, start-and-stop traffic flow, and in extreme cases, gridlock. These delays represent an opportunity cost of time, time that could be spent both at work and for leisure. Overall, this cost category has been the most studied and the greatest consensus has been reached. An estimate of excess passenger/vehicle-hours is required, and an hourly value can be applied to estimate the cost of

increased travel time.(36,37) The time loss of road users due to traffic congestion is determined, in general, by comparing the average trip time on congested links with the trip time under free-flow conditions corresponding to the design speed of the road. As traffic congestion on urban roads occurs quite frequently, mainly because of the saturation of capacity of the junctions, free-flow traffic does practically not exist within cities. The estimation of time loss due to congestion on urban roads therefore is limited to extraordinary incidents, as accidents or peak traffic volume related to festivities, sport events, fairs etc. It is used only for traffic information purposes in order to promote alternative routes and/or modes. This holds as well for rural road links in case of a temporary closing or very high traffic volumes in the vicinity of shopping centers or leisure parks. The big majority of congestion time loss occurs at daily bottlenecks.

### **2.5.2 Excess fuel usage**

According to HDR US Department of transportation traffic congestion leads to excess fuel usage due to two effects, Time spent idling in gridlock and the start-and-stop nature of travel in congested conditions. Qualitatively there is a consistent recognition of this effect, but there are not very many empirical estimates of its effect. This cost has increased in importance during the recent rise in gasoline prices. HDR's Strategic Highway Decision Support Tool (Highway DEC) model illustrates the typical relation between fuel consumption and travel speeds. Since congestion occurs primarily in urban regions increased congestion results in increased fuel costs. Estimates of congested vs. "optimal" speeds are thus required, which can then be used to compute the excess volume of fuel consumed and the resulting excess cost.[35, 37]

### **2.5.3 Increased emissions and environmental damage**

Congestion has a significant impact on routes where delivery times are heavily restricted by customer time windows and schedules. In addition, there may be a fairly inelastic relationship between delivery costs and customer's demand characteristics and levels. Also Congestion has a great impact on CO<sub>2</sub> vehicle emissions and fuel efficiency. From an operational perspective, carriers cannot take into account the impact of congestion on emissions unless time-dependent travel times are considered when designing distribution or service routes.[35,38]

The more time spent on the road, the greater are the vehicle emissions and other negative environmental externalities, such as fuel run-off into water sources, with vehicle emissions

increasing due to excessive delays, queue formation, and speed change cycles. At the local level, emissions from motor vehicles damage buildings, and in high concentrations, emissions are injurious to health. At the regional and global level, vehicle exhausts contribute to acid rain and global warming. Furthermore, emissions seem to be proportional to fuel usage, and are often measured on the basis of fuel volume consumed. It is assumed that the amount of pollutant released during motor vehicle operation is proportional with the amount of fuel consumed.[37]

#### **2.5.4 Higher accident rates and safety cost**

Accident costs arise mainly from factors such as manpower losses, vehicular damages, insurance and other exigency costs. Road safety involves three major components: the road system, the human factor and the vehicle element. These three elements are inter-linked through geo-referenced traffic events and provide the basis for road safety analyses and attempts to reduce the number of road traffic incidents and improve road safety. Road safety and road incident reduction relates to many other fields of activity including education, driver training, publicity campaigns, police enforcement, road traffic policing, the court system, the National Health Service and Vehicle engineering. Globally deaths and injuries resulting from road traffic crashes are a major and growing public health problem. The Kenyan government appreciates that road traffic injuries are a major public health problem amenable to prevention. Road Traffic accident is an unplanned occurrence of auto crash that may result in injuries, loss of lives and properties.[19] In 2005, World Health Organization (WHO) reported that traffic accidents had taken the second Leading cause of death for the people whose age is 5 to 14 next to lower respiratory, the first cause for death of people whose age is 15 to 19, and the third leading cause of death for the people whose age is between 30 to 40 next to HIV/AIDS and Tuberculosis. The latter effect reflects that crash severity increases exponentially with vehicle speed. One indication of this is that the high gas prices through the first half of 2008 were reducing accidents, in part because drivers are reducing speed to save on gas.[39]

Another indication comes from studies of the effects of changes in speed limits on road accident rates. Following 1987 federal legislation that permitted states to raise the speed limit on rural Interstate highways from 55 to 65 miles per hour (mph), states that exercised this option saw the

fatality rates on these facilities increase by 35 percent on average. For urban roads, evidence from other studies suggests that higher speed limits also increase road fatality rates.[21,40]

A recent review of the evidence on the relationship between road congestion and crashes found that: “Little research is available on the relationship between crashes and congestion as it relates to the performance of the transportation system. Although the evidence is mixed, less congested roadways appear to lead to fewer, but more severe, crashes. This relationship is especially strong in the case of crash severity; that is, more severe crashes occur on less congested roadways due in large part to faster speeds. On more congested roadways, the number of crashes may increase, but they may be primarily minor crashes reflecting the increased weaving and access/egress movements that often occur on congested road segments.[41]

### **2.5.5 Wear and tear on vehicles and higher maintenance costs**

In addition to time costs and excess fuel consumption, congestion also increases the wear-and-tear on vehicles. The start-and-stop nature of travel in congested conditions entails more strain on vehicles, primarily braking and engine systems. However, it is difficult to find empirical estimates of this cost in the literature. In this regard, this study calculated the effects of delay on other components of vehicle operating costs: motor oil, tires, maintenance, and depreciation.[35]

### **2.5.6 Loss of productivity**

The impact of traffic congestion on productivity an indirect cost has received relatively little attention compared to direct costs. Some of these impacts can be modeled within standard benefit-cost frameworks, which largely rely on the paradigm of an economy featuring perfect competition. An example is the cost to businesses from being induced by congestion to alter their choices of input supplier’s costs such as these can be captured by the induced traffic component in standard calculations of consumer surplus.[37]

Productivity losses are costs incurred due to delays experienced by commuters. The losses can be categorized into two dimensions:

- A personal dimension that covers losses arising out of personal time forgone while stuck in traffic delays. It includes time that could be used towards employment, rest or any personally gainful activity.

- A commercial dimension, especially in the freight and cargo industry. Productivity losses may stem out of canceled orders or refused shipments due to late delivery. While the first aspect that covers productivity losses has been widely studied, fewer works have taken up business impact caused by congestion. [41]

### **2.5.7 Increased inventory costs**

In order to accommodate for longer travel times, larger stocks of inventory are required, and larger buffer stocks are also necessary to accommodate increased variability of travel time. This unreliability is often found to entail a higher cost than the total travel time itself; primarily due to the requirement of buffer stock and the incidence of “stock out” costs. Along with the impact of congestion on productivity, relatively little attention has been paid to the impact on inventory costs, though this has increased in recent years with an increased focus on efficient supply chain management.[37]

## **2.6 Traffic congestion analysis**

Total delay in person-hours has been successfully used in the Urban Mobility Report for years to represent the magnitude of congestion. The Keys to Estimating Mobility in Urban Areas describes the importance and application of this measure in mobility analyses. Total delay is the sum of time lost due to congestion. Delay is typically expressed as a value relative to free flow conditions. Total delay in an urban corridor is calculated as the sum of individual segment delays. This quantity is used as an estimate of the impact of improvements on transportation systems. The value of delay time is an estimate of the average differential cost of the extra travel time resulting from congestion. As it relates to the Urban Mobility Report (UMR) methodology, this congestion cost is a function of both the time and fuel used while the motorist is in congested traffic. The cost of extra fuel consumed during congestion is computed separately from the time spent (wasted) in congestion. This report focuses on the computation of an updated value of delay time for passenger cars and trucks.[32]

The 2016 value of delay time estimate for passenger vehicle motorists and truck drivers incorporates several changes from previous estimates. The value of delay time for passenger vehicle motorists now uses the median hourly wage rate for all occupations as produced by the Bureau of Labor Statistics (BLS) as a base.[32]

Researchers estimate the 2016 value of delay time for personal travel at \$17.81 per person. The commercial value of travel time is now based on the American Transportation Research Institute (ATRI) annual survey modified by speed, type of vehicle, and vehicle occupancy and is estimated to be \$53.69 per vehicle per hour for 2016. Neither the value of delay time for personal nor commercial vehicles include the cost of fuel. The values can be used to illustrate the effect of major improvements to one portion of a corridor that affects several other elements of the corridor. The quantity is particularly useful in economic or benefit/cost analyses that use information about the magnitude of the mobility improvements for cost-effectiveness decisions. While total delay is a valuable measure for urban area analyses, delay per mile of road is more meaningful for analyses of multiple corridors.

### **2.6.1 Measure of congestion**

Measuring traffic congestion provides the data that is used in decision-making towards congestion management by documenting congestion information such as travel time, average speed, or delay time. Travel time and delay data is perhaps the most important type of data used to calibrate and validate the simulation model that supports Advanced Traveler Information Systems (ATIS) and Advanced Traffic Management Systems (ATMS) strategies for road capacity enhancement, such as traffic signal optimization and incident management on freeways and arterials. Many of the measures are currently used by transportation agencies in evaluating system performance. The measures are grouped into five categories: Time-related measures, Volume measures, Congestion indices, Delay measures, and LOS measures.[42,43] Each of the categories and measures is described in more detail below.

### **2.6.2 Time-Related Measures**

Time-related measures, which include travel time and travel rate, are widely used to evaluate congestion. One key reason is that measurement of the time it takes to travel a particular distance can be done repeatedly and can apply to all modes of travel, including the movement of goods. Travel times are the primary means of measuring performance in several ongoing intelligent vehicle-highway system-related research projects including Houston's Real-Time Traffic Information System, which uses both cellular telephone reporting and automatic vehicle identification techniques to record travel times.

Travel time is a widely used measure, applicable to a distinct starting and ending point, that highway users generally understand, with lower travel time generally interpreted as an indicator of less congestion. It is considered by many to be the best measure of system congestion. Travel time is inversely related to speed.

Origin-destination travel times is an output of the traffic assignment process of travel demand modeling, defined as the estimated time necessary to travel from an originating zone to a destination zone of a given highway network. These travel times can be estimated by calculating minimum time path skim trees.

Travel time contours is the travel time contours from a single point to/from multiple destinations/origins can be plotted on a map showing times in discrete intervals (for example, 5 or 10 minutes at a time). These are most useful for studying travel to a major employment center such as the central business district of a large city.

Percentage of time average speed is below threshold value. This spot-speed measure uses information collected from automated speed monitoring equipment. The measure uses data that can be collected in a completely automated fashion, with an increase in the value of this measure corresponding unambiguously to an increase in the degree of congestion.[12]

### **2.6.3 Volume Measures**

The wide availability of traffic volume counts and vehicle miles traveled (VMT) data make volume measures attractive to use. Because volume is a representation of the level of demand, it is often compared with the available supply, and this relationship is typically expressed in terms of a volume to-capacity ratio (V/C). It should be noted that VMT, an important measure for the purposes of air-quality analysis, is not a strong measure of congestion by itself. Density, which is also a measure of congestion, is a function of both volume and speed on a roadway segment of a given length and is directly related to freeway LOS.[43]

Real-time monitoring systems currently in use or in development can be useful for measuring travel rate, congestion levels, and even goods movement. As with other measures, the information that is produced must be recorded in a simple and cost-effective manner so as to be able to make comparisons of changes in system performance over time. Traffic monitoring

systems also are important for providing data on transportation system utilization. The Highway Performance Monitoring System (HPMS) data set includes peak-period V/C as a data item.

#### **2.6.4 Congestion index**

Congestion index is the roadway congestion index. This index is a system wide measure of congestion on the street and freeway system. The roadway congestion index uses daily VMT per lane mile of roadway for both freeways and principal arterial streets within an empirically derived formula. The index equation weighs the daily VMT per lane mile values for the two functional classes by their respective daily VMT, which is then normalized by daily VMT per lane miles representing the threshold of congestion.[2]

**Daily Vehicle-Miles of Travel:** The daily vehicle-miles of travel (DVMT) is the average daily Traffic (ADT) of a section of roadway multiplied by the length (in miles) of that section of roadway. This allows the daily volume of all urban facilities to be presented in terms that can be Utilized in cost calculations. DVMT is estimated for the freeways and principal arterial streets located in each urbanized study area. These estimates originate from the Highway Performance Monitoring System (HPMS) database and other local transportation data sources.

**Truck Percentage:** The percentage of passenger cars and trucks for each urban area was estimated from the Highway Performance Monitoring System dataset. The values are used to estimate truck travel delay and congestion costs and are not used to adjust roadway capacity estimates.

#### **2.6.5 Delay Measures**

Delays of any type increase travel time and reduce travel speeds. As such, measures of delay are closely tied to time related measures. By focusing on delay as a performance measure, specific problem locations or areas can be identified whether they are recurring or nonrecurring. A number of recent studies, focused on nonrecurring congestion, have demonstrated the importance of incident-related delays and the benefits that can be derived from their reduction.

Delay is the difference between desired or free flow and actual travel time is considered a good measure of congestion intensity on a roadway link or in an overall system. However, this measure does not give much insight into the specific causes of congestion. A minute mile of delay is the product of the length of a roadway segment and the difference between an acceptable

travel rate and the actual travel ratio (where the actual travel ratio is equivalent to 60 minutes divided by the speed on the segment).[32,44]

### 2.6.6 Level of service measures

LOS classifications, which are widely used as a measure of congestion, are derived from other performance measures. As stated in the *Highway Capacity Manual*, “the concept of level of service” is defined as a qualitative measure describing operational conditions and within a traffic stream and their perception by motorists and passengers.[45] Traffic congestion impacts can be measured based on roadway volume to capacity ratios (V/C). A V/C less than 0.85 is considered under-capacity, 0.85 to 0.95 is considered near capacity, 0.95 to 1.0 is considered at capacity, and over 1.0 is considered over-capacity. Congestion is a non-linear function, so as a road approaches its maximum capacity, small changes in traffic volumes can cause proportionately larger changes in congestion delays.[46, 47]

Highway Capacity Manual (HCM, 2010) defined "Level of Service" (L.O.S.) as a quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience. Highway capacity manual (HCM) developed by the transportation research board of USA provides some procedure to determine level of service. It divides the quality of traffic into six levels ranging from level A to level F. Level of service A represents the zone of free flow. Here the traffic volume will be less; traffic will be experiencing free flow. Level of service B represents zone of reasonably free flow; free flow speeds are still maintained at this level of service. The drivers freedom to choose their desired speed is only slightly restricted. At level of service C, the presence of other vehicles begins to restrict the maneuverability within the traffic stream. At level of service D, the average speeds begin to decline with increasing flows. Freedom to maneuver within the traffic stream is noticeably restricted. Level of service E defines operation at capacity. At this level, the stream reaches its maximum density limit. Finally, Level of service F describes conditions in a queue that has formed behind a point of breakdown or disruption.[48] However, LOS 'F' represents a failing condition, there are more factors to consider when LOS reaches F. Essentially, and LOS F either

means travel demand exceeds capacity and the roadway is operating in oversaturated conditions, or another undesirable condition exists.[49]

Table2. 1 Urban street LOS criteria

	I	II	III	IV
Range of free-flow	90 to 70 km/h	70 to 55 km/h	55 to 50 km/h	50 to 40 km/h
Typical free-flow	80 km/h	65 km/h	55 km/h	45 km/h
Level of Service	Average Travel Speed (km/h)			
A	> 72	> 59	> 50	> 41
B	> 56 - 72	> 46 - 59	> 39 - 50	> 32 - 41
C	> 40 - 46	> 33 - 46	> 28 - 39	> 23 - 32
D	> 32 - 40	> 26 - 33	> 22 - 28	> 18 - 23
E	> 26 - 32	> 21 - 26	> 17 - 22	> 14 - 18
F	≤ 26	≤ 21	≤ 17	≤ 14

Source: HCM 2000

## 2.7 Performance measure traffic delay of congestion

In this section, a set of commonly used performance measures that reflect congestion levels on roads are briefly explained their distinguished.

Travel rate index is the index computes the “amount of additional time that is required to make a trip because of congested conditions on the roadway.” It examines how fast a trip can occur during the peak period by focusing on time rather than speed. It uses both freeway and arterial road travel rates.[46]

Travel time index is the index compares peak period travel and free flow travel while accounting for both recurring and incident conditions. It determines how long it takes to travel during a peak Hour and uses both freeway and arterial travel rates. It is the ratio of average peak travel time to an off-peak travel time, speed of 96km/hr is considered for freeways. Travel time index of 1.20 means average peak travel times are 20% longer than off-peak travel times.

Travel delay is the extra amount of time spent traveling because of congested conditions. The TTI study divided travel delay into two categories: recurring and incident.

Travel rate is expressed in minutes per mile, is how quickly a vehicle travels over a certain segment of roadway. It can be used for specific segments of roadway or averaged for an entire

facility. Estimates of travel rate can be compared to a target value that represents unacceptable levels of congestion.[32]

Delay rate is “the rate of time loss for vehicles operating in congested conditions on a roadway segment or during a trip.” This quantity can estimate system performance and compare actual and expected performance. Relative delay rate is the relative delay rate can be used to compare mobility levels on roadways or between different modes of transportation. This measure compares system operations to a standard or target. It can also be used to compare different parts of the transportation system and reflect differences in operation between transit and roadway modes. The delay ratio can be used to compare mobility levels on roadways or among different modes of transportation. It identifies the significance of the mobility problem in relation to actual conditions.[46,32]

### **2.7.1 Total delay measure**

Total delay was chosen as a performance measure because it relates to delay and the data needed to calculate this measure are readily available. The travel times can be derived by using speed and the length of a route. This measure will help transportation professionals determine the delay for all vehicles traveling over a segment of roadway during a specific time period and thus to assess the severity of the congestion. Total delay could also allow transportation professionals to estimate how improvements within a transportation system affect a particular corridor or the entire system.

Total delay may be useful to traffic managers because it represents delay for all vehicles. Time lost for all vehicles is more important for roads that have higher volumes because higher volumes mean that more travelers are affected by the time lost, which can mean more community money is wasted. A comparison of delay among different segments of roadway is also possible when using total delay. Total delay shows the effect of congestion in terms of the amount of lost travel time. The sum of time lost on a segment of roadway due to congestion for all vehicles is represented by total delay as follows:

Total delay (PCU-hr) = [Actual travel time (hr) – Acceptable travel time (hr)] x Traffic Volume.[32]

Table 2. 2 summary of congestion measures

1	$\text{Travel rate} \left( \frac{\text{min}}{\text{km}} \right) = \frac{\text{Travel time}}{\text{Segment length}} = \frac{60}{\text{Average speed}}$
2	$\text{Delay rate} \left( \frac{\text{min}}{\text{km}} \right) = \text{Actual Travel rate} - \text{Acceptable travel rate}$
3	$\text{Delay ratio} = \frac{\text{Delay rate}}{\text{Actual travel rate}}$
4	$\begin{aligned} &\text{Delay per traveler(Annual - hrs)} \\ &= [\text{Actual travel time} - \text{FFS travel time}] \times \frac{250 \text{ days}}{\text{year}} \times \frac{\text{hours}}{60 \text{ minut.}} \end{aligned}$
5	$\begin{aligned} &\text{Travel time(person - hours)} \\ &= \text{Actual travel rate} \left( \frac{\text{min}}{\text{km}} \right) \times \text{Length} \times \text{vehicle volume} \\ &\quad \times \text{vehicle occupancy} \left( \frac{\text{per}}{\text{veh}} \right) \end{aligned}$
6	$\text{Travel time index} = \frac{\text{Actual travel rate} \left( \frac{\text{min}}{\text{km}} \right)}{\text{FFS travel rate} \left( \frac{\text{min}}{\text{km}} \right)}$
7	$\begin{aligned} &\text{Total delay(pcu - hrs)} \\ &= [\text{Actual travel time(hr)} - \text{Acceptable travel time(hr)}] \times \text{Traffic volume} \end{aligned}$

Source: (Tim Lomax, Shawn Turner, and Gordo Shunk) [12, 50]

## 2.8 Congestion Costing

Congestion costs are part of the external costs of road transport, like the costs of accidents, noise, pollution, space consumption and physical or visual barriers. Their significance is to a large extent time and location sensitive. Improved vehicle technology, higher safety standard of roads, more environmentally-friendly accommodation of road infrastructure, as well as dynamic traffic management may contribute to a reduction of external costs, but the continued growth of car ownership and mobility is likely to outweigh the favorable impacts.

- Annual congestion cost in the United Kingdom (UK) will reach 33.4 billion US\$ by 2030, rising by over 50% from the 2014 levels of 20.5 billion US\$.[12]
- Annual cost of congestion in the United States (US) as of 2014, has been pegged at 124 billion US\$; this is projected to increase to 186 billion US\$ by 2030.[1]
- In Australia, annual congestion cost levels are expected to rise from Australian Dollars (AUD) 3.5 billion (2005) to AUD 7.8 billion (2020) for Sydney, and AUD 3.0 billion (2005) to AUD 6.1 billion (2020) for Melbourne [18].

The economic value of congestion reductions can be difficult to evaluate because congestion tends to maintain equilibrium: traffic volumes grow until delays discourage additional peak-period trips. It also has indirect effects, such as land use development patterns and economic productivity that are difficult to measure. Increasing traffic congestion does impose costs not only on travelers but also on the whole economic activities and finally affects national income. It has been difficult to develop and apply empirical measures of the extent of those economic costs. Various methods are used to quantify congestion costs.[29] One approach is to determine the price needed to reduce traffic volumes to optimal roadway capacity, which indicates consumers' willingness-to-pay for increased mobility and therefore the actual cost they place on delay.[51] Another approach is to calculate the marginal impacts each vehicle entering the traffic stream imposes on other road users, taking into account the speed-flow relationship of each road segment.[52] However, the data needed for such analysis is seldom available so most estimates are based on simplified models that measure incremental delay, vehicle costs and emissions over some baseline. Monetized values are assigned to the additional time and emissions. Higher travel time unit costs (dollars per hour) are sometimes applied to congested conditions to reflect additional driver stress and unreliability.

Congestion costs are part of the external costs of road transport, like the costs of accidents, noise, pollution, space consumption and physical or visual barriers. Their significance is to a large extent time and location sensitive. Improved vehicle technology, higher safety standard of roads, more environmentally-friendly accommodation of road infrastructure, as well as dynamic traffic management may contribute to a reduction of external costs, but the continued growth of car ownership and mobility is likely to outweigh the favorable impacts.

Investments in road transport increase net social welfare only if the total social benefits exceed social costs.[53] Thus, potential benefits of lower production costs and consumer prices, greater variety in product choice, faster delivery, and spin-off effects such as value-adding or employment in related economic sectors, due to improved accessibility should be higher than the total costs of investment, operation, maintenance, and external effects.

It is clear that increasing traffic congestion does impose costs upon travelers and affect broader Business operations; it has been difficult to develop and apply empirical measures of the extent of the traffic congestion and its economic costs. Even though, proper measuring the extent or level of congestion is an important step for understanding the performance of the existing road network, for evaluation of proposed congestion mitigation measures and for evaluation of cost of congestion.[50,54]

The valuation of external effects, i.e. by putting a monetary value on the effects which are by definition not priced, enables a quantitative comparison of the magnitude of different external effects, as well as an evaluation of economic and social costs and benefits. However, as Verhoef emphasizes, the interpretation of the validated externalities should be done very carefully, because the absolute values are very sensitive to the methods used.

### **2.8.1 Value of travel time**

The Value of Travel Time refers to the cost of time spent on transport. The Value of Travel Time Savings refers to the benefits of faster travel that saves time. Travel time is one of the largest categories of transport costs, and time savings are often the greatest expected benefit of transport improvement projects. Factors such as traveler comfort and travel reliability can be quantified by adjusting travel time cost values. On average people devote 60-90 minutes a day to travel. Most people seem to enjoy a certain amount of personal travel, about 30 daily minutes, and dislike devoting more than about 90 minutes a day). [55] Travel time *costs* (the disamenity of time spent traveling, and therefore the value of travel time savings) are the product of time spent traveling multiplied by unit costs (e.g., cents per minute or dollars per hour). Travel time unit costs vary depending on type of trip, travel conditions, and traveler preferences.[48, 47] .For example, time spent relaxing on a comfortable seat tends to impose less cost than the same amount of time spent driving in congestion or standing on a crowded bus. Walking, cycling, waiting, and

travelling as a passenger or driver may each have different unit costs which vary depending on travel conditions, needs and user preferences; For example, a person might one day enjoying a relaxed recreational walk or drive, but another day may pay generously for faster travel when rushing to an important event. Travel time unreliability (uncertainty how long a trip will take, and unexpected delays) imposes additional costs.[5, 6]

## 2.9 Summery and Gap analysis

One of the significance is the traffic congestion issue as a global phenomenon in the management of capital cities, giving the level of population and activity concentration. Traffic congestion continues to remain a major problem in most cities around the world, especially in developing regions resulting in massive delays, increase fuel wastage, environmental pollution increase, and monetary losses.

Traffic congestion has various negative impacts ranging from economic losses to adverse environmental and social impacts. Congestion causes increased costs for travelers and freight movement, loss of time, accidents, increase transport cost, increase vehicle operating cost and psychological strain. These researches focus the impact of congestion on socio-economic activities. It is analysis and identified the impact or the effect product losses, travel time lost, waste fuel, environmental pollution, increase travel time cost, increase vehicle cost. The other one analysis and measuring congestion travel time delay assessing the impact and analysis of wasted economic cost of travel time in birr due to congestion.

The need of this research we can predict what will happen in the future, due to the fact that every person living working or even who made a visit within the city is affected or touched differently by the existing road traffic congestions, leaving aside its general impact on peoples' socio-economic impact in the city. It has expecting to show how the traffic congestion has affected the residents of Addis Ababa city socially and economically. The research provided relevant recommendations and suggestions in accordance to the nature of the findings as well as relating it to the current national transportation policy. Also, the research pin pointed some areas which require future investigation in the future on condition that there will be a gap between it and other studies on the problem.

## **CHAPTER THREE**

### **3 RESEARCH METHODOLOGY**

#### **3.1 Introduction**

This chapter describes the methodological framework used in attaining the stated aim and objectives of the study. It shows how the research questionnaires or hypothesis postulate empirically determine and examine relevant methodological approaches adopted in the study. The research design, type and sources of data are examining along with the procedure employees in testing the questionnaires and accomplishing the study objectives. In particular, focus is one the study populations/sample frame and its characteristics, sampling technique chosen, and a description of the choice of data collection instruments, questionnaire design and methods of data measurement, in this chapter.

#### **3.2 Description of study area**

Addis Ababa is the capital city of the Federal Democratic republic of Ethiopia, is located in the center of the country. Established in 1886, the city has experienced several planning changes that have influenced its physical and social growth. Addis Ababa has the status of both a city and a state. It is where the African Union and its predecessor the OAU are based. Addis Ababa is therefore often referred to as the political capital of African, due to its historical, diplomatic and political significance for the continent. The city is populated by people from different regions of Ethiopia-the country has as many as 80 nationalities speaking 80 languages and belonging to a wide variety of religious communities. It is home to Addis Ababa University.[56] Addis Ababa Addis Ababa city Administration extends over 540equ.kms with 10 sub cities and 99 kebeles for administrative purpose. As pre the master plan from urban transport system (2004/2006) the administrative units are further divided in to 131 traffic analysis zone. The city has experienced spatial spread mostly towards the southern, eastern and South Western parts of the main city. The spatial spread is mainly guided by topography and road network development.

Due to large of the city this thesis focused from Megenagna roundabout to CMC Michael urban road segment. This road segment is very crowded especially during peak hours relative to mid-day. Because of they have residential settlement, different site construction available; merchants

and business of activities were involved and governmental institution found it. The other one also passing the vehicles through these segment individual vehicles. It is very effect due to some people only travel on the way and cause congestion. The length the study of road segment is 4.46 km and shown below the figure including map of Addis Ababa city and study corridor.

Table 3. 1 Length of taken road segment

Road segment	Length (m)	Travel Time (sec)
Megenagna – gurd shola	500	7:00 AM -6:00 PM
Gurd shola- Civil service University	486	7:00 AM -6:00 PM
Civil service-CMC Michael	460	7:00 AM -6:00 PM



### **3.2.1 Population of Addis Ababa city**

Addis Ababa is the capital and biggest city of Ethiopia. It consists of a population of 3,384,569 as per the 2007 population enumeration, with yearly growth rate of 3.8%. This number has been expanded from the initially published 2,738,248 figure and gives off an impression of being still to a great extent underestimated. It has the status of a city as well as a state. It is the place the African Union is and its antecedent the OAU was based. It likewise has the central station of the United Nations Economic Commission for Africa and various other international organizations. The city is populated by individuals from various districts of Ethiopia. According to central statistics agency (2017), It has the total population are 328,9000 ,male 154542 and female 174358. Total area is covered 122.08 square kilometer.[57]

### **3.2.2 Population density and growth of Addis Ababa**

The population density of Addis Ababa is 5165 persons per square kilometer. As of now, the population growth rate of the city is 3.8% and this rate has been consistent since quite a while. The population growth rate is not great and it is one of the reasons why the number of people living here has not increased by a higher number. It is estimated that the population growth of Addis Ababa city.[57]

### **3.3 Research Approach**

The research approach in this thesis involves both quantitative and qualitative approaches. Quantitative data and analysis were used to determine the total congestion cost, traffic volume analysis, average travel time analysis, delay measures and level of service of urban segments. A qualitative research methodology covers a number of alternative techniques, including questionnaire and review of secondary data source. A direct field measurement was the main sources of quantitative data. Furthermore, qualitative data from questionnaire were also used to determine whether the congestion in the segment is impact or not and to assess other related parameters.

### 3.4 Types and Sources of Data

Required and type of data are from primary and secondary sources. The primary data were obtained through questionnaires occupiers involved in the study. This is the type of data which are collected through questioner with respondents. Questionnaire as a series of questions, each providing a number of alternative answers from which the respondents can choose. Hence questionnaire can be considered in general terms in which each person is asked to respond to the same set of questions in a predetermined order. It is stratified in to the same character of population that, public servant, private servant, driver and students. The other way of primary data collected traffic volume, travel time data and salary earning in months in the field. It is important to determine the congestion analysis and total economic cost of congestion.

#### 3.4.1 Sample size

It is usual, when using statistics, to plan data size at the same time as planning data collection. This enables you to have high level of confidence as well as a small margin of error. Before we can calculate a sample size, we need to determine a few things about the target population and the sample it needs:

Population size: How many total people fit the demographic and Margin of error (confidence Interval): No sample will be perfect, so you need to decide how much error to allow. The confidence interval determines how much higher or lower than the population means you are willing to let the sample mean fall. Confidence Level means how confident do we want to be that the actual mean falls within our confidence interval. The most common confidence intervals are 90% confident, 95% confident and 99% confident. For this thesis 95% confident level were taken. To determine the sample size based on Cochran (1963) and Morgan table value developed equation which is apply when the population greater than 100,000.

$$n = \frac{Z^2 \times P(1-P)}{e^2} = \frac{1.96^2 \times 0.5(1-0.5)}{0.05^2} = 384.16 \text{ therefore, we can take } 385.$$

Where: n= Sample size required for the study

Z= Critical value (=1.96) for the 95 percent confidence level, the amount of uncertainty that one can tolerate. Most researchers recommend 95per cent confidence level.

$P$  = Proportion of people expected to have the basic knowledge about the problem. (i.e. 0.5) because the Morgan table value recommended for 50 percent for the value of 'P'.

$e$  = Margin of error that can be tolerated: it is the discrepancy between the sample size and the population. The recommended value is 5per cent ( $=0.05$ ).

The other once the video recorded data was acquired, extracting travel time taken by an individual vehicle to travel a specified length of a road section was determined by tracing every individual vehicle. Since many vehicles negotiate the entry point at a time, vehicles were selected randomly but statistically significant sample size was determined for each 15-30 min of count. The sample size was determined according to the procedure and equation on the Travel time handbook. However, the hand book using the above statistical equation provides a sample sizes for different traffic conditions and level of confidence. Accordingly, for congested traffic condition at 90% confidence interval and +10% errors, the minimum sample size was calculated to be 18 for 15-30min count. Therefore, for 15min interval about minimum of 18 vehicles travel time were recorded in the case of this research.

### **3.4.2 Primary Data**

Primary data collection technique used for questionnaire type and its structured questions was developed to gather additional information on the perception of road users about the segments traffic congestion. The questionnaire also helped the researcher to identify congested segments on the same. The questioners were distributed randomly for road users (public servants, private servants, drivers and students) along the road corridor. The total sampling size can be determined based on Cochran (1965) and Morgan table value of developed equation. Hence the total number of sample size has been 385 of the total population of involved around the study area. After the sample size made prepared the questionnaire about the impact of road congestion on socio-economic activities. Then distributed the questionnaires based on simple random sampling and judgmental sampling techniques were involved. After that, we have collects the questionnaire survey and check the whole questions answered. The other way of data gathering involved field measurement on the study area. From field measurement collected data like traffic volume and travel time based on 15 minutes interval video recorded.

Value of time can be considered using questionnaires type which was based on the above number of sampling. It collects different trip makers around from our study area using monthly salary value. The value of time needs to calculate the total travel economic cost of congestion.

### **3.4.3 Secondary Data**

Secondary data means data are already available and published. They refer to the data which have already been collected and analyzed by someone else. It also used to unpublished thesis were adapted. Thus, secondary data provide second hand information and include both raw data and published ones. It includes books, journal articles, newspapers, report and publications of various associations and organization as well as other documentary reviews from internet.

### **3.4.4 Research design**

This section addressed the plan, structure, and strategy of investigation of issues related to the socio-economic impact of road traffic congestion in Addis Ababa city in case of Megegnagna CMC Michael road segment road segment. The plan outline, while the strategy shows the means by which the research is executing and the methods adopted in data collection and analysis. The methods are follows design in such a way that the key questions of the research will be answer properly. First, Information on the socio-economic and demographic characteristics (such as sex, age, education, types of occupation, and position, impacts of social, economic, and political problem, impacts of result delay and wastage of time, wastage of time, health and environmental pollution effect, psychological effect, led to accident, operating cost, and just in case time and extra transportation cost etc.) of the impact of road traffic congestion on socio-economic activities are generating through questionnaire administration. The questionnaire is administering on public societies, private societies, students and drivers who formed the population using random sampling and judgmental sampling techniques. Second, to estimate the proportion of traffic congestion three major traffic bottlenecks are selects on the major roads in the study area. The traffic count was carried out video camera and manually was adapted. The exercise was carried out for three alternate days (i.e. Monday, Wednesday and Friday). The peak hour traffic study was particularly useful. Because it provides important information concerning the maximum traffic loads imposed upon the road network. Data collection was started from morning to night (7:00AM – 6:00PM).

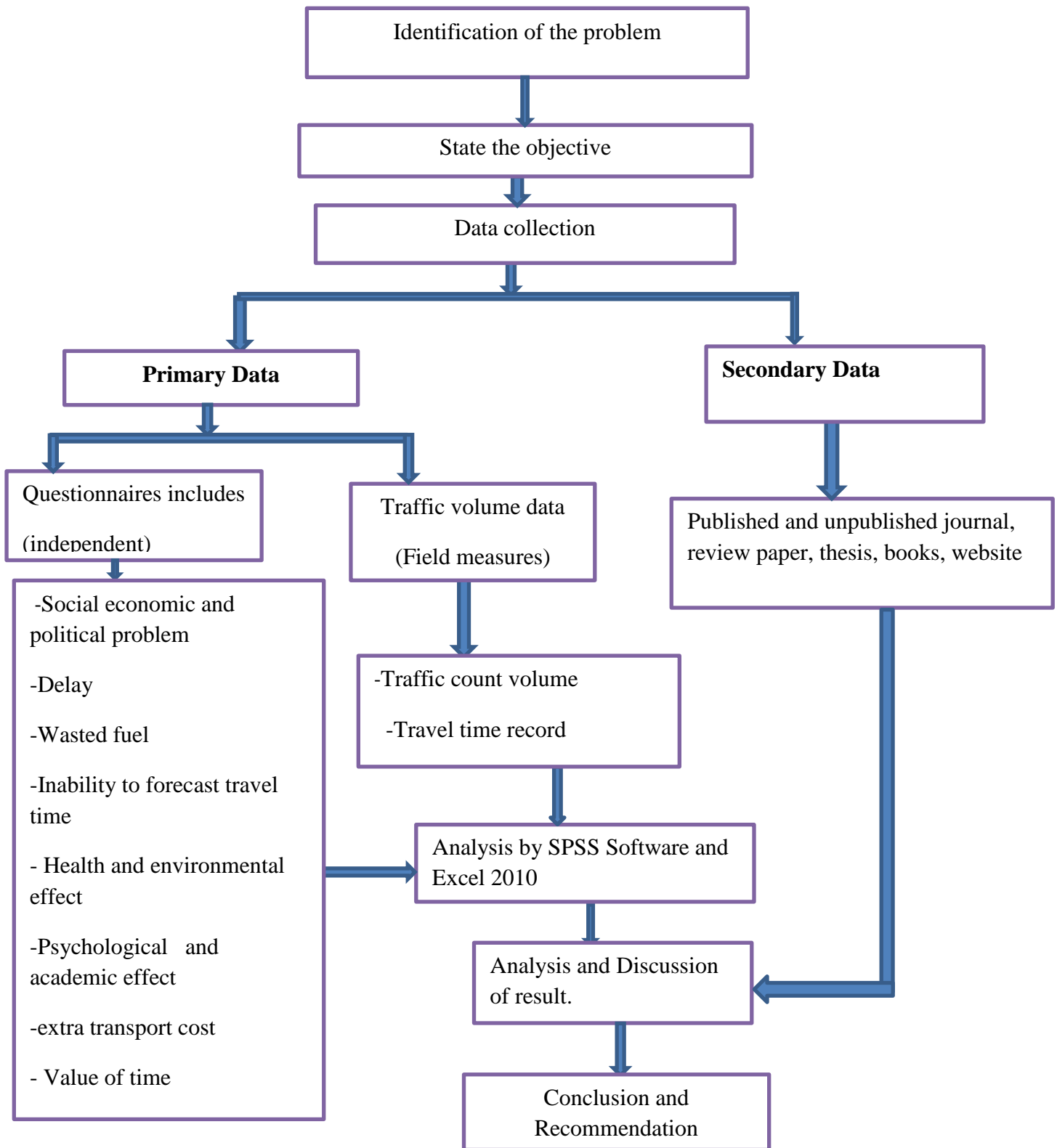


Fig.3.2 General Design of research

### 3.5 Methods of Data Collection

To attain the objectives of this research, different types of quantitative and qualitative data were needed. The qualitative data are including to the regarding to related socio-economic activity. Like, social, economic, and political problem, wastage of fuel, wasted time, health and environmental problem, psychological and academic effect of community, extra transportation cost, increase vehicle operating cost, led to increase accident all of this are developed the questionnaire and distributed population using simple random sampling techniques. The quantitative data were derived from field measurement data like, traffic volume, travel time, and value of time can be considered and taken from the trip makers. After that, we have used to general formula and procedures can be followed. The following parameters were needed to analysis the quantitative data. Like, delay, vehicle occupancy, average speed, Value of time (VoT) and total economic cost of travel time congestion. Both primary and secondary data source were used and descriptive statistics approaches was adapted. Samples were selected randomly system from these sample groups using simple random and judgmental sampling techniques. Records of road traffic congestion situations which occurs during peak hours and off hours volume of vehicle and the questionnaire is administering on public societies, private societies, students and drivers who formed the administering on public societies, private societies, students and drivers who formed the population using simple random sampling techniques from which samples are selecting for this study.

Value of time can be considering the trip makers travel from megenagna to CMC Michael road segment. The questioner was based on the trip traveler monthly earning in Ethiopia birr. The sampling techniques were adapted simple random and judgmental sampling methods.

Video recording were used to collect travel time data. This method of travel data collection relies on video cameras to collect or capture the traffic flow in the field and human personnel to transcribe or trace vehicles into a database at the office after the actual time of data collection. According to travel time collection handbook; though it is costly, video capturing techniques is preferred over the manual collection. From accessible area was used and collects data by 15 minutes time interval. The questionnaire is administering on public societies, private societies, students and drivers who formed the population using random sampling and

judgmental sampling techniques. Second, to estimate the proportion of traffic congestion three major traffic bottlenecks are selected on the major roads in the study area.

### **3.6 Methods of data analysis**

The process of data analysis aims at determining whether the questionnaires support the research questions that are formulated before going into the field to collect the information. With regards to this study, the data collected are edited for accuracy and completeness before they are subjected to analysis. Descriptive statistics were used for and describe by frequency tables, average, one way analysis of variance and charts to summarize the data for better analysis. The questionnaires were prepared on socio-economic impact of traffic congestion was done using Statistical Package for Social Sciences 22 (SPSS) and excel 2010. In analyzing the data, based on answers from different respondents, field's measurement and information obtained from documents are thoroughly checked out and compared to establish their validity. Analysis of data is basically based on the number of sample size using scaling methods. This paper's main method of analysis statistics was analysis of variance.

The demography analysis can be described by descriptive statistics like percentage and graphs. One way analysis of variance is in statistics a technique that can be used to compare means of two or more samples. The tests of the null hypothesis that samples in all groups are drawn from population with the same mean value. The significant value (P-value) of the mean variance can be compared from the postulated margin of error which is 0.05 or 5% and known as alpha level. If the p-value is less than the alpha the significant but greater insignificant. Finally we can analyze the total travel time of economic cost of congestion and delay using excels.

## **CHAPTER FOUR**

### **4 ANALYSIS OF RESULT AND DISCUSSION**

#### **4.1 Introduction**

This chapter presents the analysis and discussion of the findings of the study. The presentation is organized according to the research specific objectives and research questions. Improving the social and economic wellbeing of the citizenry is the aim of every nation. The long-term goal of government is to raise the standard of living of all Ethiopia to a level consistent with that of middle income economy. One basic economic and social necessity that comes into focus when discussing economic and social development is transportation. Transportation is an activity of life processes and seeks to provide access to various activities that satisfy mobility needs of humankind. Urban transportation refers to the system of transportation that provides access and mobility for people and goods within cities. Elements of urban transportation include public transit (collective transport); non-motorized transport (pedestrians, cyclists) and freight. Effective urban transport systems are essential to economic activity and quality of life. Urban transportation opens up opportunities to access essential services as well as social activities.[7,49] states that congestion can be perceived as unavoidable consequences of scarce transport facilities such as road space, parking area, road signals and effective traffic management. They argue that urban congestion mainly concerns two domains of circulation, passengers and freight which share the same infrastructure. Thus, traffic congestion condition on road networks occurs as a result of excessive use of road infrastructure beyond capacity, and it is characterized by slower speeds, longer trip hours and increased vehicular queuing.

#### **4.2 Statistical Analysis**

Analysis of variable is used to test a hypothesis concerning the mean of two or more than population. Data were analyzed using Statistical Package for Social Sciences (SPSS) software.

It is used to test whether the impact significant or not. One way analysis of variance is in statistics a technique that can be used to compare means of two or more samples. The significant value (p-value) of the mean variance can be compare from the postulated margin of error which is 0.05 or 5% and known as alpha level. Descriptive statistics is a summary statistic that

quantitatively describes or summarizes features of a collection of information. It is describes information different mechanisms like using mean, standard deviation, variance, range, minimum and maximum value, sum, by graph, diagram, table and percent etc. For this paper we can use by table and graph as shown below the descriptive statistics of output results and one way analysis of variance.

#### 4.2.1 Sex profile respondent

The aim was to include all respondents with consideration of gender. The study was to cover about 385 respondents participated through questionnaires. Out of the total respondents about 44.7 percent were male and 55.3 percent were females. The observation of variation in gender has very small. Shown below the table the aim was to provide an equal chance to both male and female respondents to identify their views concerning the socio-economic impact of road traffic congestion in Addis Ababa city in case of Megenagna to CMC Michael road segment. The assumption was that males and females (Public servants, Private servants, drivers and students) have different experiences of traffic congestion.

Table 4. 1 The respondent of sex

	Frequency	Percent	Valid Percent	Cumulative Percent
Male	172	44.7	44.7	44.7
Valid Female	213	55.3	55.3	100.0
Total	385	100.0	100.0	

#### 4.2.2 Age profile of respondents

Age of the respondents could be classified in five groups, which are between. Generally, the study was to cover about 385 respondents participated through questionnaires. Shown in below the age covered about 32.7 percent were 18-25 years, 47.8 percent were 26-35 years, 15.6 percent were 36-45 years, 3.6 percent were 45-55 years and 0.3 percent was above 55 years.

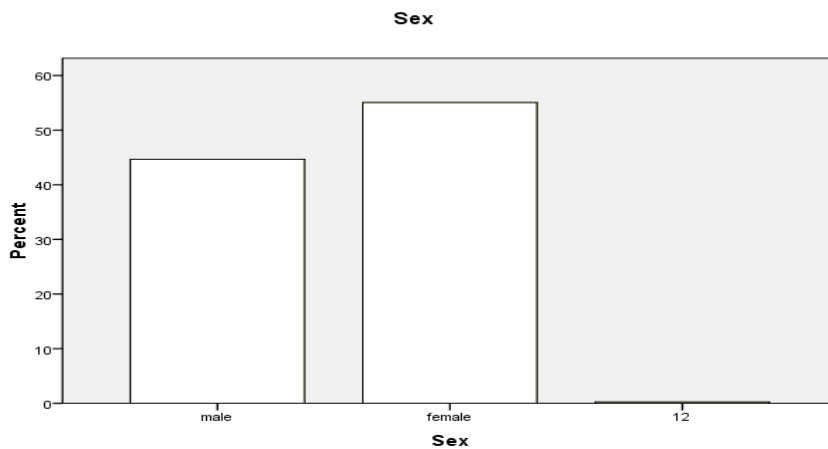


Fig.4. 1 Age profile of respondents

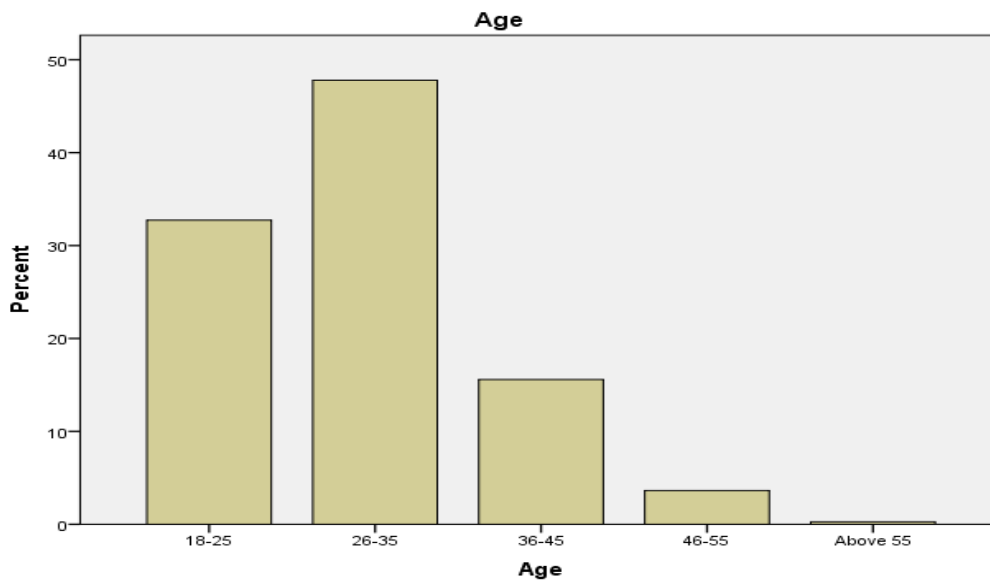


Fig.4. 2 Age profile of respondent

### 4.2.3 Educational level respondent of profile

To participation of the questionnaires of this paper the percentage of educational level shown in below the table grouped in to five. As we can see most of the respondents were 65.7 percent degree level 17.4 percent were secondary level, 1.3 percent master and above and 15.6 diploma level. This is very important to concentrate the issue and give the reality of impact of congestion.

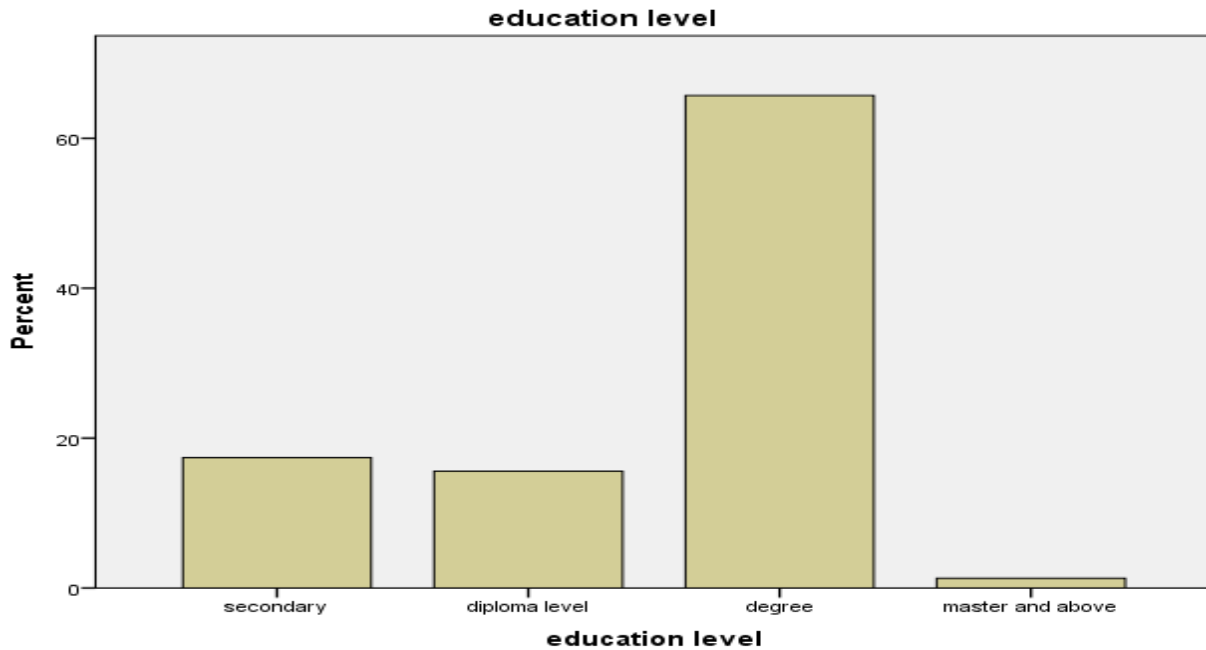


Fig.4.3 Education level of respondent profile

#### 4.2.4 Type of occupation of respondent of profile

The targeted respondents were those who are employed, public employed, private employed, self-employed and student. The types of occupation of the respondents were most of employed in public servants. Here is 44.4 percent public employed, 24.9 percent were private employed, 16.4 percent were self-employed, 14.3 percent were students.

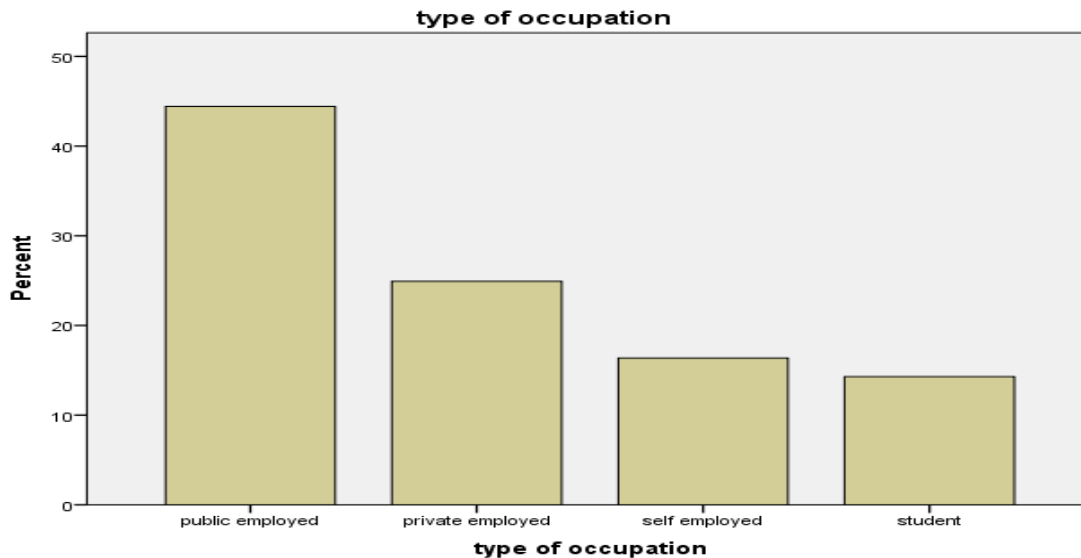


Fig.4. 4 the type of occupation of respondent of profile

### 4.3 Socio-economic impact of road traffic congestion

Traffic congestion has a number of negative effects in Addis Ababa city. Traffic congestion is a condition on transport networks that occurs as use increase, and is characterized by slower speeds, longer trips times, and increase vehicular queuing. When traffic demand is great enough that the interaction between vehicles slows the speed of the traffic stream this results in some congestion. Generally the following elements are the negative impact of road traffic congestion in Addis Ababa city and its including analysis of the questionnaires are Social, Economic, and Political problem, Delay which is result in late arrival for employment, Inability to forecast travel time, Wasted fuel increasing air pollution and carbon dioxide emission, Wear and tear on vehicles as a result of idling in traffic and frequent acceleration and braking, leading to more frequent repairs and replacement, Wasting time due to congestion, Psychological and academic effect on students, Social affair precipitation on community, Health and environmental problem on the community, led to increase accident, extra cost of transportation on the community level, to increase vehicle operating cost. All the above elements were included the questioners and analysis of SPSS Software.

### 4.3.1 Social economic and political problem

Traffic congestion costs consist of incremental delay, vehicle operating costs (fuel and wear), pollution emissions and stress that result from interference among vehicles in the traffic stream, particularly as traffic volumes approach a road’s capacity. Social impact refers to the effect of an activity on the social fabric of the community and well-being of the individuals and family. In business and government policy, social impact refers to how the organization’s actions affect the surrounding community. According to the output result as shown below the table the respondents were 92 percent response strongly agree and agree and for the problem of socio, economic and political problem in case of megenagna to CMC Michael road segment. The analysis of one way mean analysis of variance of output result shows that the significant value is 0.020. Since P-value is less than 0.05 then impact of congestion on social, political and economic problem.

Table 4. 2 Traffic congestion impact on social, economic and political problem

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid strongly disagree	8	2.1	2.1	2.1
Valid Disagree	8	2.1	2.1	4.2
Valid Neutral	15	3.9	3.9	8.1
Valid Agree	164	42.6	42.6	50.6
Valid strongly agree	190	49.4	49.4	100.0
Total	385	100.0	100.0	

### 4.3.2 Excess time delay

The added unpredictability of travel time is including the cost. There is also the associated inability to travel time accurately, leading to drivers allocating more time to travel “ just in case” less time on productivities. In addition to the travel time delay, there is further, indirect, cost of congestion on road users. The first is delay, which is the cost to transport users if the level of congestion causes them to alert their travel plans by leaving their origin either early or late. As

shown below the output result 89.1 percent were strongly agreed and agree. This indicates most of respondents agree to the problem of the impact.

Table 4. 3 Traffic congestion impact results delay

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid strongly disagree	10	2.6	2.6	2.6
Disagree	11	2.9	2.9	5.5
Neutral	21	5.5	5.5	10.9
Agree	162	42.1	42.1	53.0
strongly agree	181	47.0	47.0	100.0
Total	385	100.0	100.0	

#### 4.3.3 Inability to forecast travel time

Inability to forecast travel time accurately, leading to drivers allocating more time to travel “just in case” and less time on production activities. According to the result 93.8 percent respondents were strongly agreed and agreed for the problem. Based on mean analysis of variance the p-value is 0.018 and it’s less than 0.05. Since it indicates the travel time of the passenger cannot accurately forecast.

Table 4. 4 Traffic congestion impact inability to forecast travel time

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid strongly disagree	7	1.8	1.8	1.8
Disagree	4	1.0	1.0	2.9
Neutral	13	3.4	3.4	6.2
Agree	176	45.7	45.7	51.9
strongly agree	185	48.1	48.1	100.0
Total	385	100.0	100.0	

#### 4.3.4 Wasted fuel of congestion

Wasted fuel increasing air pollution and carbon dioxide emissions owing to increased idling, acceleration and braking. The other one is also wasted fuel which naphtha and diesel increased due to traffic congestion. As we can see the output result the respondents were 94.1 percent strongly agree and agreed. The wasted of fuel output results shows the p-value is 0.021 less than 0.05 and indicates the congestion is effect on fuel.

Table 4. 5 Traffic congestion impact wasted fuel

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	7	1.8	1.8	1.8
Disagree	5	1.3	1.3	3.1
Valid Neutral	11	2.9	2.9	6.0
Agree	172	44.7	44.7	50.6
strongly agree	190	49.4	49.4	100.0
Total	385	100.0	100.0	

#### 4.3.5 Wasting time

Research findings demonstrated that many working hours are lost daily on the way during traffic congestion. As shown below the table out of 385 respondents 53.5 percent strongly agree, 40.3 percent agree the remains percent were the other scale. Due to congestion high delay occurred and wasting of time is increase. As shown table 4.13, the p-value is 0.042 less than the recommended error value (0.05).

Table 4. 6 Traffic congestion impact wasting time

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	8	2.1	2.1	2.1
Disagree	5	1.3	1.3	3.4
Valid Neutral	11	2.9	2.9	6.2
Agree	155	40.3	40.3	46.5
strongly agree	206	53.5	53.5	100.0
Total	385	100.0	100.0	

#### 4.3.6 Psychological and academic effect

Road traffic congestion impact is one of effects on psychological and academic issue on the students and community. It refers to negative consequences which have effects to the behavior, thoughts or emotions of an individual. As shown below the table the respondents were 57.4 percent strongly agree and 38.4 percent were agreed. The significant value of it is 0.033 less than 0.05 and its accepted effect on socio-economic activities.

Table 4. 7 Traffic congestion impact psychological and academic effect on students

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	5	1.3	1.3	1.3
Disagree	4	1.0	1.0	2.3
Valid Neutral	7	1.8	1.8	4.2
Agree	148	38.4	38.4	42.6
strongly agree	221	57.4	57.4	100.0
Total	385	100.0	100.0	

#### 4.3.7 Social participation

Social participation means to involve different issues like, meeting, market, edir, ekub, appointment, wedding, etc. The effect of road traffic congestion in social affairs participation on the community highly effect. Here the result conclusion most of the respondents were 50.9 strongly agree and 43.4 percent agreed. Total the effect of community participation poor due to road traffic congestion as we see from the respondent about 94.3 percent were strongly agreed and agree. The value of the significant is 0.047 less than 0.05.

Table 4. 8 Traffic congestion impact effect on social affair participation on the community

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	3	.8	.8	.8
Disagree	6	1.6	1.6	2.3
Valid Neutral	13	3.4	3.4	5.7
Agree	167	43.4	43.4	49.1
strongly agree	196	50.9	50.9	100.0
Total	385	100.0	100.0	

#### 4.3.8 Health and Environmental problem

Congestion has a great impact on CO<sub>2</sub> vehicle emissions and fuel efficiency. From an operational perspective, carriers cannot take into account the impact of congestion on emissions unless time-dependent travel times are considered when designing distribution or service routes. The health and environmental problem of led to vehicle emission increase with congestions due to the stop-and-go driving congestions, and the total amount of emissions is inefficiently high due to excess traffic volume. The main hazards are climate change, deterioration of air quality and noise. According to the result below the table 92.5 percent respondents were strongly agreed and agree for the problem of the congestion. The results indicate that health impact of traffic congestion on the community exists and should be considered when evaluating policy

alternatives for addressing congestion in the study area. The various health challenges resulting from traffic congestion could reduce the productivity of the passengers.

Table 4. 9 Traffic congestion impact health and environmental problem on the community

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	8	2.1	2.1	2.1
Disagree	10	2.6	2.6	4.7
Valid Neutral	11	2.9	2.9	7.5
Agree	155	40.3	40.3	47.8
strongly agree	201	52.2	52.2	100.0
Total	385	100.0	100.0	

#### 4.3.9 Traffic accident

Traffic congestion condition results in higher accident rate, which translates in to additional costs to automobile users. Accident is the worst in the world especially developing country. Addis Ababa is also high traffic accident occurred during different time. As shown below the result of SPSS software analysis of descriptive statistics 93.7 percent were respondents strongly agree and agree for the problem of road traffic congestion which led to increase accident.

Table 4. 10 Traffic congestion impact led to increase accident

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	6	1.6	1.6	1.6
Disagree	7	1.8	1.8	3.4
Valid Neutral	11	2.9	2.9	6.2
Agree	161	41.8	41.8	48.1
strongly agree	200	51.9	51.9	100.0
Total	385	100.0	100.0	

#### 4.3.10 Transportation cost

The expenses involved in moving products or assets to different places, which are often passed on to consumers. In economics the cost associated with the exchange of goods or services and incurred in overcoming market imperfections. On order to see transport is the basic need of our life but the effects of extra transport cost well happen due to road traffic congestion. Hence, like business productive decrease, transport cost increase. According to the result of output value respondent response 56.6 percent strongly agree and 34.5 percent agree which is 91.1 percent agree for the effect or impact of congestion on extra transport cost.

Table 4. 11 Traffic congestion impact extra transportation cost on the community

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	9	2.3	2.3	2.3
Disagree	3	.8	.8	3.1
Valid Neutral	22	5.7	5.7	8.8
Agree	133	34.5	34.5	43.4
strongly agree	218	56.6	56.6	100.0
Total	385	100.0	100.0	

#### 4.3.11 Operating cost

Vehicle operating cost increase in congested traffic conditions due nature of a travel wear and tear on vehicles as a result of idling in traffic and frequent acceleration and braking, leading to more frequent repairs and replacement. It increase length of time that vehicles spend on the network increase the vehicle operating cost for users, primarily through increased fuel cost. Additionally, high traffic volumes represent operating cost in excess of the socially optimal level. Vehicle operating cost is directly proportionate to the traffic congestion. A vehicle operator applies more breaks and accelerates again and again. So, the lifetime of vehicles parts and fuel consumption will be more in road congestion. As shown the output result below the table 88 percent of respondents were strongly agreed and agreed on the problem of increase

vehicle operating cost. The output results show the p- value is 0.019 less than 0.05 and it indicates high impact on vehicle operating cost.

Table 4. 12 Traffic congestion impact increase vehicle operating cost

	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	5	1.3	1.3	1.3
Disagree	7	1.8	1.8	3.1
Valid Neutral	34	8.8	8.8	11.9
Agree	134	34.8	34.8	46.8
strongly agree	205	53.2	53.2	100.0
Total	385	100.0	100.0	

#### 4.4 One way mean analysis of variance

As earlier states, one way analysis of variance is in statistics a technique that can be used to compare means of two or more samples. The significant value of the mean variance can be compare from the postulated margin of error which is 0.05 or 5% and known as alpha level. If the p-value is less than the alpha then all factors are significant at 0.05 but greater insignificant. Shown in below the table 4.13 statistically one way mean analysis of variance the p-value of parametric variable are impact on social, economic and political problem, Traffic congestion impact results delay, inability forecasting travel time, wasted fuel, Wear and tear vehicles, Wasting time, psychological and academic and environmental problem on community, increase accident, extra transportation cost, and increase vehicle operating cost. Based on this information all p- value is less than alpha level ( $p < 0.05$ ) so that, all are these factors significant. However, according to traffic congestion is the impact and effect of socio-economic activities in Addis Ababa city in case of megenagna to CMC Michael road segment.

Table 4. 13 One way mean analysis of variance

Congestion impacts of Variables		S.Squares	df	M. Square	F	Sig.
Traffic congestion impact on social, economic, and political problem	Between Groups	.191	2	.095	.139	.020
	Within Groups	261.472	382	.684		
	Total	261.662	384			
Traffic congestion impact results delay	Between Groups	.519	2	.260	.325	.043
	Within Groups	305.185	382	.799		
	Total	305.704	384			
Traffic congestion impact inability to forecast travel time	Between Groups	.619	2	.310	.530	.018
	Within Groups	223.266	382	.584		
	Total	223.886	384			
Traffic congestion impact wasted fuel	Between Groups	1.849	2	.924	1.568	.021
	Within Groups	225.258	382	.590		
	Total	227.106	384			
Traffic congestion impact on wear and tear vehicles	Between Groups	1.450	2	.725	1.257	.031
	Within Groups	220.326	382	.577		
	Total	221.777	384			
Traffic congestion impact wasting time	Between Groups	.540	2	.270	.428	.042
	Within Groups	241.133	382	.631		
	Total	241.673	384			
Traffic congestion impact psychological and academic effect on students	Between Groups	.946	2	.473	.935	.033
	Within Groups	193.298	382	.506		
	Total	194.244	384			
Traffic congestion impact effect on social	Between Groups	.588	2	.294	.587	.047
	Within Groups	191.246	382	.501		

affair participation on community	Total	191.834	384			
Traffic congestion impact health and environmental problem on the community	Between Groups	.386	2	.193	.275	.034
	Within Groups	268.247	382	.702		
	Total	268.634	384			
Traffic congestion impact led to increase accident	Between Groups	1.367	2	.684	1.147	.029
	Within Groups	227.609	382	.596		
	Total	228.977	384			
	Within Groups	263.532	382	.690		
	Total	263.990	384			
Traffic congestion impact increase vehicle operating cost	Between Groups	.448	2	.224	.330	.019
	Within Groups	259.178	382	.678		
	Total	259.626	384			

#### 4.5 Congestion Analysis

According to Banjo, G.A. defined congestion as the saturation of road network capacity due to regular and irregular reductions in service quality exemplified by increased travel times, variation in travel times and interrupted travel. Traffic congestion is a condition on road networks that occurs as use increases, and is characterized by slower speeds, longer trips, and increased vehicular queuing. Congestion analysis was made based on the travel time approach for the determination of congestion measures. While performing the analysis only one approach with traffic volume and found on megenagna to CMC Michael urban street road segment was selected for each segment as follows.

- Megenagna to Gurd-shola road segment
- Gurd-shola to Civil service University
- Civil service University to CMC Michael road segment.

The travel time, traffic volume and vehicle occupancy, delay, delay rate, actual travel rate, and delay ratio were used to analyze the congestion along the study corridor. The congestion analysis

was based on the travel time approach and hence the following congestion measures were analyzed. These are; Average travel speed, travel rate, delay rate, delay ratio, total segment delay, buffer index and travel planning time index. Accordingly, the analysis of each congestion measures are presented in the following sections and the output result attach in the appendix.

#### 4.5.1 Traffic volume

Traffic volume data are very important to determine and understand the flow pattern in the facility, to determine the peak flow rates and peak periods, to assess the relationship between traffic volume and congestion. Traffic volume count was conducted to determine the number, movements, and classifications of roadway vehicles at a given location. These data can help identify critical flow time periods, determine the influence of large vehicles or pedestrians on vehicular traffic flow. Traffic volume data is the fundamental input value for this paper. Traffic volume data are very important to determine and understand the flow pattern in the facility, to determine the peak flow rates and peak periods, to assess the relationship between traffic volume and congestion. Furthermore, it is extremely required to analyze the level of service of a facility and quantify the congestion intensity. It collects and gathered the data were recorded using video camera within 15 minutes time interval starting morning to night (7:00 AM – 6:00 PM). The duration of traffic data were taken three day. (i.e. Monday, Wednesday and Friday) were recorded. The daily traffic volume was converted passenger car unit (PCU). The vehicles were counted in category as “Passengers car” and “Goods vehicles”. The Passengers cars category includes vehicle types namely; Cars and Taxi, 4WD, Minibus Taxi, Mid-Bus and standard Bus, where as the Goods Vehicle category includes vehicle types namely; Small truck, Medium truck and Heavy trucks.

Table 4. 14 Passenger Car Equivalent factors

Vehicle	Passenger vehicle					Goods vehicles		
Type	Car & Taxi	4WD	Small bus	Medium bus	Large bus	Small truck	Medium truck	Large truck
PCU	1	1	1.5	1.5	3	1.5	3	3

Source: HCM 2000 and 2010

The traffic volume analysis is done for both direction and three mid blocks along the Megenagna to CMC Michael corridor. Traffic volume data shown in appendix table 4.15 and the

road sections or the mid blocks considered are from: Megenagna to Gurd – shola , Gurd – shola to Civil service University and Civil service university to CMC Michael.

#### 4.5.1.1 Megenagna to Gurd-shola

This section of the road starts at the megenagna round about to Gurd shola which was took the mid-block of length of the segment 500m located. This road section carries traffic from the residential areas of the north direction of the city. Figure below shows that the traffic volume for the direction of Megenagna to Gurd shola road segment is peak hours during the morning is increase and it decrease to the mid-day and shows a slight increase and become nearly steady from 2:00 PM to 6:00 PM.



Fig.4. 5 Trend of Megenagna of congestion

#### 4.5.1.2 Gurd-shola to Civil service University

This section of the road starts at the Gurd-shola to Civil service University. The length of the mid-block road segment was taken 486m. This road section carries traffic from the residential areas of the north direction of the city and they have different main road and local road intersects. Figure 4.8 below shows that the traffic volume for the direction of Gurd shola to Civil service University road segment is peak during the morning is increase and it decrease to the mid- day and shows a slight increase and become nearly steady from 2:00 PM to 6:00 PM.



Fig.4. 6 Trends of near to Gurd-shola congestion

#### 4.5.1.3 Civil service University to CMC Michael

This section of the road starts at the Civil service University to CMC Michael. This road section carries traffic from the residential areas of the north direction of the city and they have different main road and local road intersects. Figure 4.8 below shows that the traffic volume for the direction of Gurd-shola to Civil service University road segment is peak during the morning is increase and it decrease to the mid- day and shows a slight increase and become nearly steady from 2:00 PM to 6:00 PM.



Fig.4. 7 Trends of CMC congestion

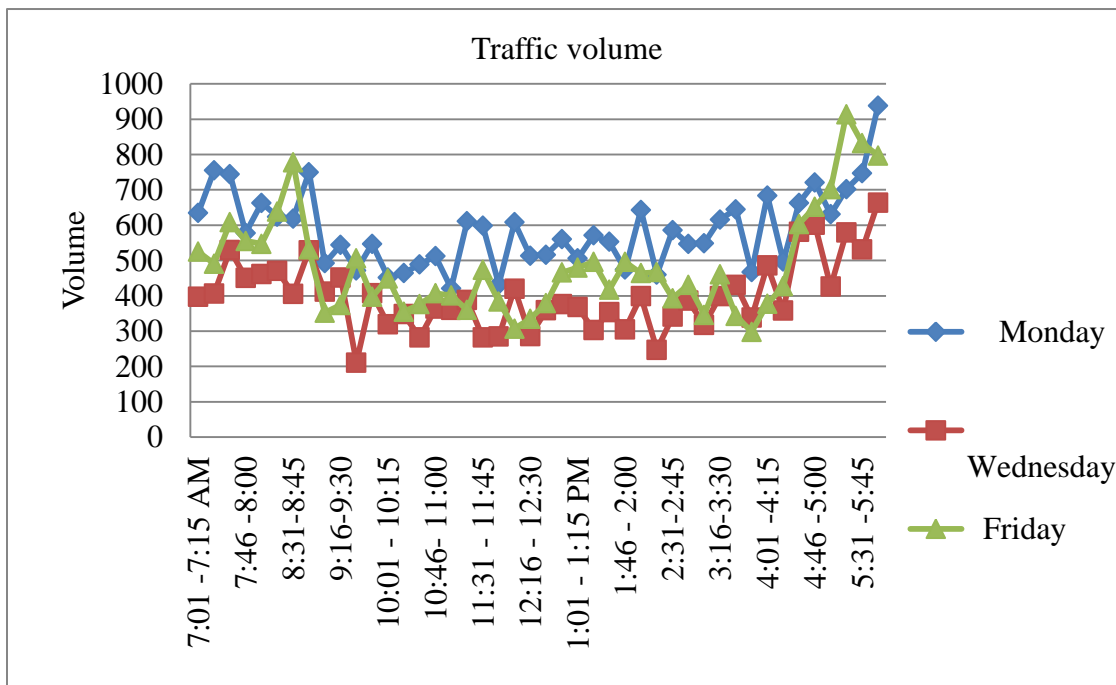


Fig.4. 8 Traffic hourly volume Megenagna to CMC Michael

#### 4.5.2 Travel time

Travel time is one of the largest categories of transport costs, and time savings are often the greatest expected benefit of transport improvement projects. Factors such as traveler comfort and travel reliability can be quantified by adjusting travel time cost values. Spending excessive amounts of time in travel (particularly congested commuting) seems to reduce life satisfaction. Travel time measures offer the best means for estimating the economic impacts of the congestion. Travel time corresponds directly to the traveler's experience of congestion, when measured from a given origin to destination; To estimate the direct user costs of congestion are based on placing a value on travel time, often as a percentage of the wage rate; and Most traffic models produce estimates of speed and time for individual roadway segments and origin and destination zones. In order to collect the average travel time data at the selected locations, the procedures described on travel time data collection handbook (1998) were followed. Data of actual travel time required for vehicles to pass the section of the roads was collected for starting morning hours to night hours (7:00 AM – 6:00 PM) was measured using stop watch. The travel time data were recorded three days (Monday, Wednesday, and Friday) within 15 minutes and minimum of 18 samples were recorded. After data collection of travel time, it was taken the average travel time. The appendix table 4.16 shows the average travel time at 15-min interval for the segments selected. According to the result, the morning and evening peak periods recorded the higher travel time and the lowest travel time recorded during the mid- day or lunch time. When at peak period there is increase the numbers of vehicle volume were as at the mid-day decrease.

#### 4.5.3 Travel speed

Travel speed represents the ratio of segment length to through-movement travel time. Travel time is computed as the sum of segment running time and through-movement control delay at the downstream boundary intersection. The average travel speed can be considered using the travel time and length of road section. The congested speed were determine the length of road segment divided by the average time that to complete the length of the section. Traffic congested is a condition on transport that as use increase and is characterized by slower speeds, longer trip times and increase vehicular queuing but average speed means the total distance traveled by the

vehicle divided by the elapsed time to cover the distance. Free-flow speed represents the average running speed of through automobiles traveling along a segment under low-volume conditions and not delayed by traffic control devices or other vehicles. It reflects the effect of the street environment on driver speed choice. Elements of the street environment that influence this choice under free-flow conditions include speed limit, access point density, median type, curb presence, and segment length.[58] Free-flow travel time considers as based on highway manual urban street and can be taken class IV range between 40 to 50 km/hr and the average speed is considers 45 km/hr. Since the average travel time in free-flow speed is 40 sec with the length of road segment as taken 500m, 486m, and 460m respectively. For this thesis we can be consider based on Highway capacity manual urban street criteria average free-flow speed at 45 km/hr. The average speed analysis at the congested road sections considered in this study is shown in the appendix table 4.17. The result shows that during the peak hour the average speed of the vehicle is 10.6 km/hr and in mid-day 22.2 km/hr.

#### **4.5.4 Vehicle occupancy data**

Vehicle occupancy; which is the number of peoples per vehicles, is an extremely important parameter in traffic engineering and transportation planning. Usually it is used to convert person trip to vehicle trip. Hence, vehicle occupancy is very important parameter for calculating congestion intensity parameters. To calculate the vehicle occupancy is capacity of vehicle type multiply by total number of vehicles it's having capacity divided by total volume moving the segment. The vehicle occupancy data shown is attached in the appendix table 4.18-19.

#### **4.6 Delay Performance Measures**

Delay is typically expressed as a value relative to free flow conditions. Delay, speed, travel time and Level of service are the most dominant the measurement of congestion.

Total delay in an urban corridor is calculated as the sum of individual segment delays. This quantity is used as an estimate of the impact of improvements on transportation systems. Total delay is the sum of time lost due to congestion. Total delay can be a useful measure:

- To estimate the total duration of congestion of an urban area.
- To illustrate the effects of major improvement to one portion of a corridor that affects several other elements of the corridor.

- To perform economic or benefit/cost analysis that use information about the magnitude of the mobility improvements for cost-effectiveness decisions.
- Congested travel can be a useful measure for estimating the spatial extent of congestion of an urban area.
- Congested roadway length is simple to calculate and easy for the public and policy makers to comprehend.[46]

#### 4.6.1 Delay

Traffic delays consist of those under uncongested traffic condition and those under congested traffic condition. When the traffic volume exceeds the work zone capacity, traffic congestion occurs and, therefore, results in vehicle queues and traffic delays. For example, the Dutch Road Authority estimated that annually, 44 million hours are lost due to congestion in the Netherlands. This is equivalent to a loss of 700 million Euros when translated into monetary costs. It was also discovered that 57% of commuters and motorists spend between 30 to 60 minutes on the road due to traffic congestion.[59] It is the difference between actual travel time and free-flow travel time. The delay analysis were conducted from Megenagna to CMC Michael road segment and it analysis three station of mid corridors.

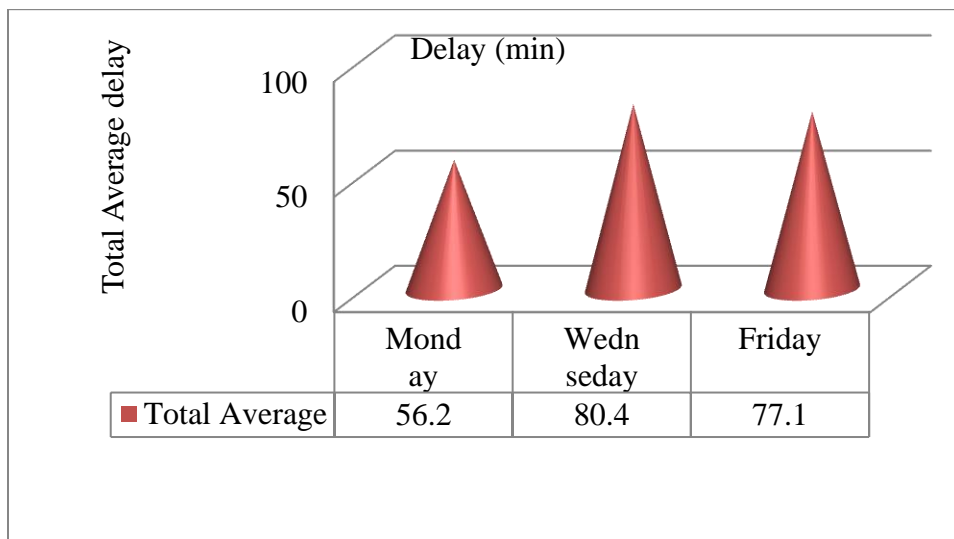


Fig.4. 9 Total average delay

The above figure states that the total average delay for Monday is 56 minute, for Wednesday 80.4 minute and 77.1 minute for Friday. The analysis of delay shown appendix table 4.20-22 and

the total average delay is in three days are 213.7 minutes or 3.56 hrs were lost due to traffic congestion. As it indicate the travel time cost loss increasingly due to congestion. Hence based on delay analysis result congestion is high impact of socio-economic cost peoples.

#### 4.6.2 Actual Travel Rate

Travel rate, expressed in minutes per km, is how quickly a vehicle travels over a certain segment of roadway. It can be used for specific segments of roadway or averaged for an entire facility. Estimates of travel rate can be compared to a target value that represents unacceptable levels of congestion. The actual travel rate for this urban segment is increasing during peak hours but in mid-day its decrease. Since the travel rate increase indicates traffic congestion is also increase. As shown the appendix 4:20-22 the average travel speed is decrease the actual travel rate is increase during peak hours' time.

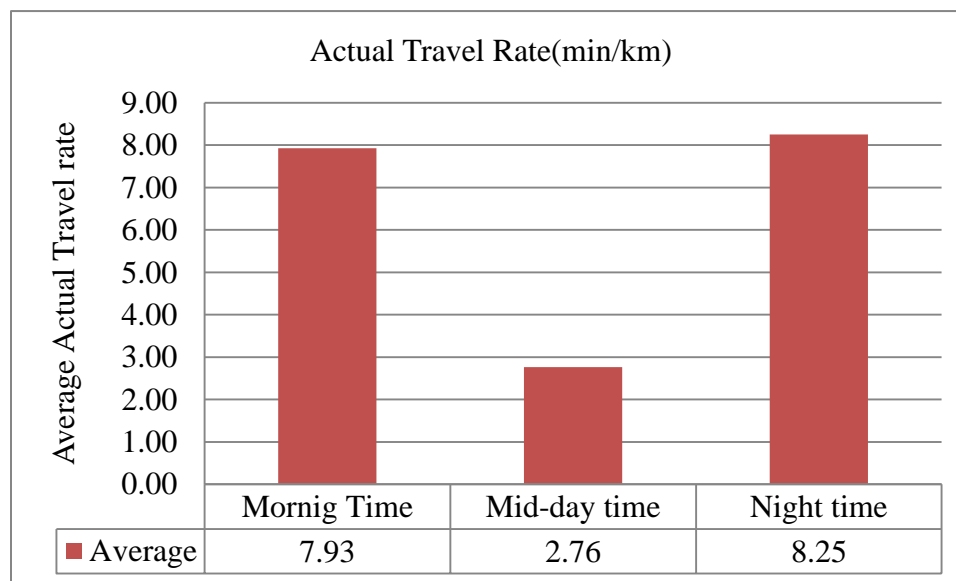


Fig.4.10 Average actual travel rate

This figure shows that, the morning and at night (work to home and home to work) the average actual travel rate is increase well as the mid-time is decrease. It indicates the travel speed is very decrease especially during peak hour time. The actual travel rate is increase the speed of the vehicle is decrease.

### 4.6.3 Delay Rate

This quantity can estimate system performance and compare actual and expected performance. As shown below the figure the result of analysis of average delay rate morning and night (work to home and Home to work) is greater than the mid- day. As this indicates it has high level of congestion for this road segment. The analysis of delay rate shown in the appendix table 4:20-22. As compare delay rate to relative speed of vehicles low during the peak period but delay rate increase as shown below the figure 4.8. The average delay rate during peak period is 6.76 min/km and during mid-day is 1.43 min/km.

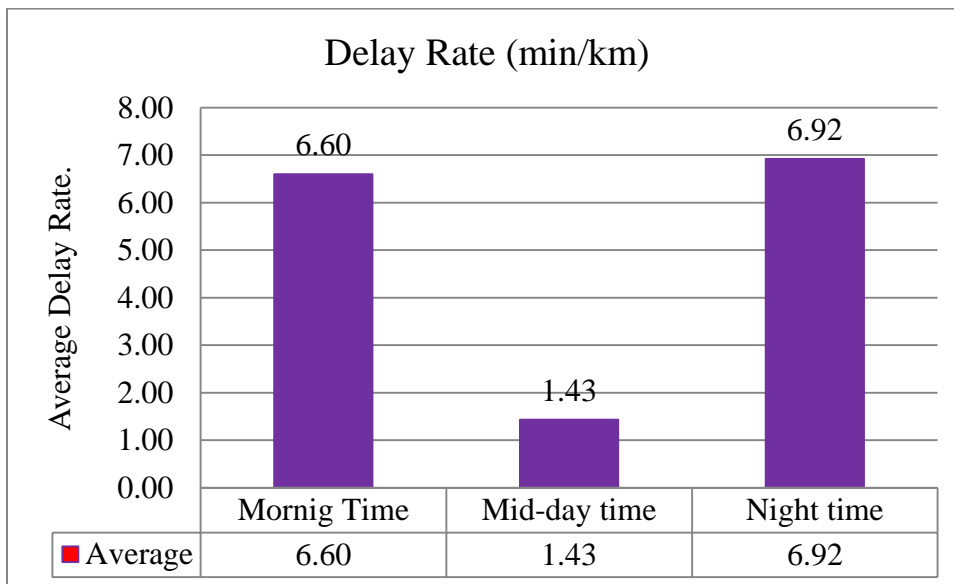


Fig.4. 11 Average delay rate

### 4.6.4 Delay Ratio

The delay ratio can be used to compare mobility levels on roadways or among different modes of transportation. It identifies the significance of the mobility problem in relation to actual conditions. As shown the appendix table 4:20-22 the delay ratio during peak hour is increasing but in free-flow time relatively decreasing. The delay ratio during peak hours has 83 percent and mid-day has been 51 percent. Since the delay ratio increase the speed of vehicles decline.

#### 4.6.5 Delay per Traveler

Delay per traveler is one of the measures of traffic congestion delay indicators. It can be analysis using the average travel time and free-flow travel time through the years. Since the total average delay per traveler from Megenagna to CMC Michael road segment is 890.4 annual hours of working day. As shown below the figure the peak hour delay per traveler is greater than mid-day and it indicates high congestion during morning and night. The analysis of total average delay per traveler attached in the appendix table 4:20-22 respectively.

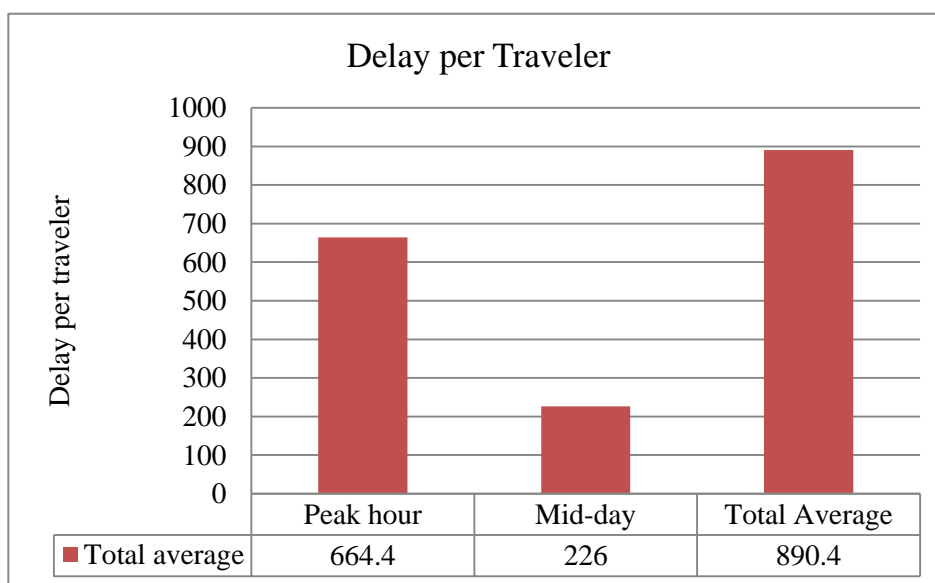


Fig.4. 12 Average delay per traveler

#### 4.6.6 Travel Time Index

Travel time index is the ratio of travel time in the peak period to the travel time at free-flow condition or it compares peak period travel and free flow travel while accounting for both recurring and incident conditions. This index is expressed by comparing travel time in free flow condition and the one in peak hours. Index has the advantage of expressing traffic congestion in terms of both space and time. It is the ratio of average peak travel time to an off-peak travel time, speed of 96km/hr is considered for freeways. Travel time index of 1.20 means average peak travel times are 20% longer than off-peak travel times. As shown the appendix table 4:20-22 the

average travel time index is 6.0 for peak hour but in mid-day 2.1. Since this indicates the travel time index increase the delay also increase.

#### 4.6.7 Total Segmental Delay

Total segment delay: measured in Person-hour is the measure of congestion intensity. It shows how the congestion is serious and indicates the extent of the congestion that how much peoples being affected with the congestion. Total delay shows the effect of congestion in terms of the amount of lost travel time. The sum of time lost on a segment of roadway due to congestion for all vehicles is represented by total delay as follows:

Total delay (PCU-hr) = [Actual travel time (hr) – Acceptable travel time (hr)] x Traffic Volume.

The figure below shows that, the total volume of vehicle increase and speed of vehicle decrease total segment delay is increase. The total segment of road traffic delay in the segment shown in below and 3850.59 pcu-hours lost due to congestion.

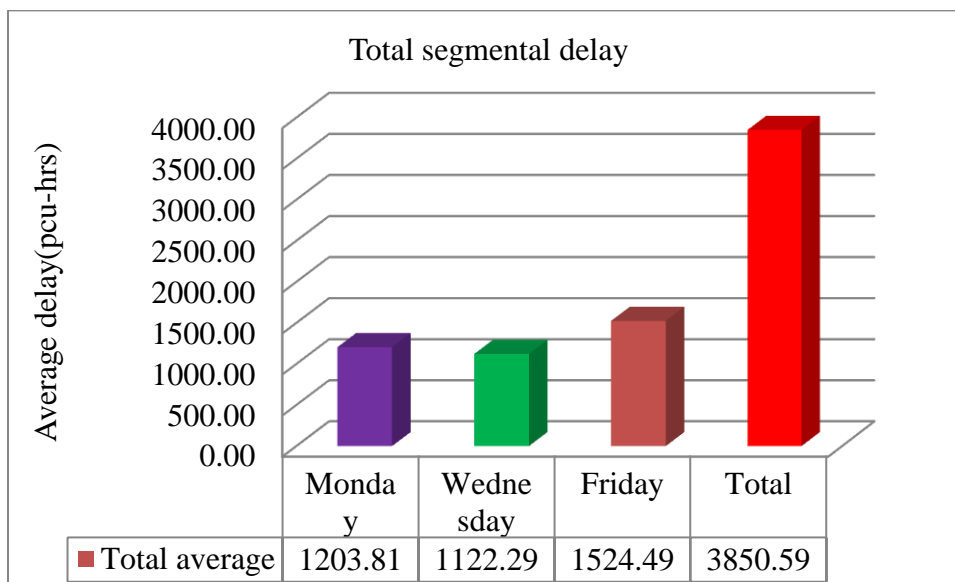


Fig.4. 13 Total segmental delay

#### 4.7 Economic cost of Travel Time Congestion

Travel time unit costs vary depending on type of trip, travel conditions, and traveler preferences. Congestion is affects the socio-economic impact where in urban area. In this section, we have analysis the total cost of congestion having considered the various components of that contribute to the total cost of congestion. Economic cost of traffic congestion is one of the most debatable

issues in an economy. Traffic congestion in roads has a massive cost impact on the production and the general work life of many people. Traffic congestion has not only impacted passenger transportation also the freight transportation. Most of developing countries suffer enormous financial and labor time losses due to road traffic congestion. The congestion cost value is difficult to determine the fact value. Addis Ababa road high congested especially during peak hours due to peoples travel to work area and back to home.

The economic travel time cost of congestion analysis methodology based on the application of Speed-flow conditions. The method of calculating congestion costs is based on comparing the speed at uncongested flow conditions with the speed in congestion flow conditions. Since, time at free-flow speed minus time at actual speed multiplied by hourly volume and multiplies by value of time. As shown the figure indicates the total economic travel time cost of congestion the first segment is 13372802.56 birr/hr the second is segment is 13833684.86 birr/hr and the last segment is 1569264.73 birr/hr. Based on this, the total economic travel time cost of congestion from Megenagna to CMC Michael road segment is 42,897752.15 birr waste due to road traffic congestion Shown appendix table 4.23- 25

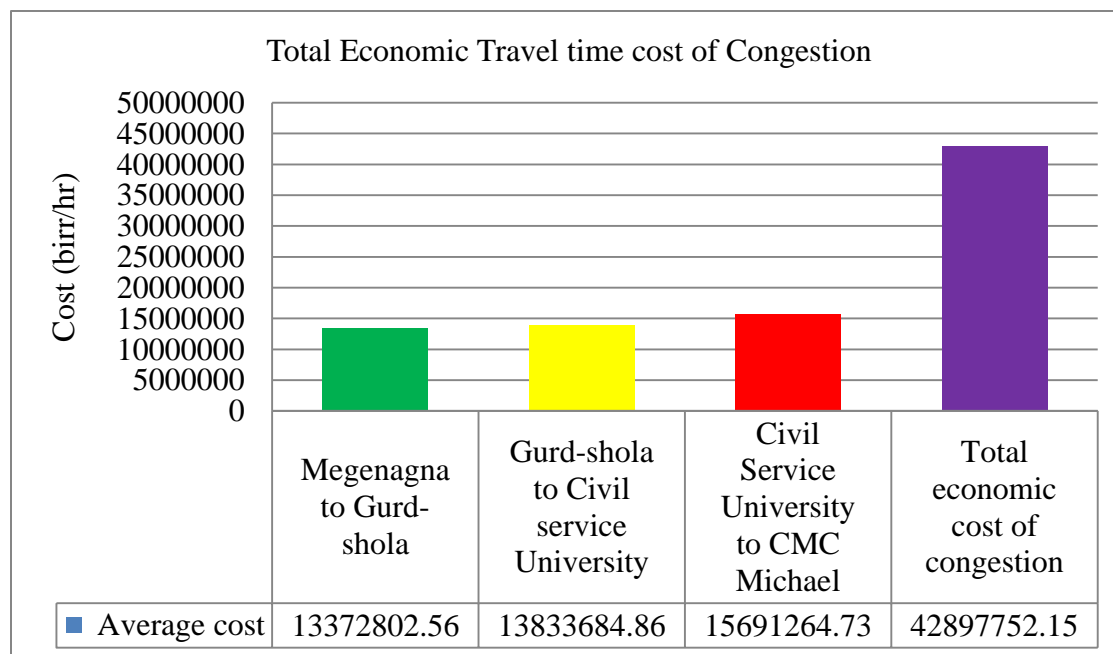


Fig.4. 14 Total estimated economic cost of congestion

#### 4.7.1 Value of time

There are many different costs which are result of aggravated congestion. These include lost time to road users, emissions, vehicle operating cost costs, and wider economic impacts. In this study, we are specifically analyzing the value of time lost to road users as a result of aggravated congestion. Value of time is the amount that a typical traveller would be willing to pay to save on travel time. For in-work travel, value of time measures a direct economic benefit, putting a value on the benefits to a business of reduced travel times, in terms of greater productivity (less time travelling means more time available for productivity activity), improved access to suppliers and customers and a wider potential market.

The value of time was estimated the unit value of time of a person in Addis Ababa which was consider from the road segment Megenagna to CMC Michael trip makers. Those, we have estimated using questioners addressed to the stake holders. For this research the value of time can be consider based on the monthly salary (Birr per month). After that, it changes to hourly volume that means we have to consider 8 work hours of a day and 22 working days a month. Average monthly earnings per person in Addis Ababa (only focused the trip from our study area) is ETB 5682.18 per month, Hourly income would be birr 32.28. According to European academic research (2015) the average value of time in Ethiopia for business trip is taken as the hourly income of ETB 19 per hourly.[58]

#### 4.8 Level of service

According to HCM defines six levels of service, ranging from A to F, for each service measure, or for the output from a mathematical model based on multiple performance measures. LOS A represents the best operating conditions from the traveler's perspective and LOS F the worst. For cost, environmental impact, and other reasons, roadways are not typically designed to provide LOS A conditions during peak periods, but rather some lower LOS that reflects a balance between individual travelers' desires and society's desires and financial resources. According to HCM LOS is defined by two performance measures. In order to this the average travel speed of three segments from megnagna to CMC Michael road segment is 16.6 km per hour respectively. Based on highway capacity manual 2010 urban street LOS criteria this road segment is E.

## CHAPTER FIVE

### 5 CONCLUSIONS AND RECOMMENDATION

#### 5.1 Conclusions

This thesis discusses urban street segmental assessment of socio-economic impact of road traffic congestion. Traffic congestion is one of the significantly recognized urban transport problems. It continues to remain a major problem in most cities around the world, especially in developing regions resulting in massive delays, increased fuel wastage, time losses and monetary losses. The issue of traffic congestion in Addis Ababa city is becoming a serious challenge to effective flow of people and goods in the city. The study focused and assessed the socio-economic impact of road traffic congestion on passenger's time losses and etc. Based on this research finding the following conclusion was made.

- Generally, Transport in Addis Ababa is chaotic, inefficient, unreliable and dangerous. Traffic congestion during the morning and night peak hour is more than that of the mid-day and wasted fuel and losses of time is high relative to the mid-day. Due to road traffic congestion loss of productivity, inhibiting human development and reducing the quality of life, change in accident frequency and characteristics, increase in air pollutants and emissions, increased vehicle operating costs and increased noise nuisance, increase wastage of time, increase delay, increase wastage of fuel, lack of comfort.
- Delay is the first thing many people think of when it comes to congested road. Traffic congestion delays people to their places of work and the consequence of this is that many working hours are lost on the way, which is a great challenge to the employers. Due to road traffic congestion, which results late arrival for employment, meeting and education, resulting in lost business, disciplinary action inability to forecast travel time accurately and other personal losses.
- Congestion is the impact of social, economic and political problems in Addis Ababa city. Wasted fuel is increasing, losses of extra transportation cost and increasing the operating cost for the community. Even if, it is the wear and tear on vehicles as a result of idling in traffic and frequent acceleration and braking, leading to more frequent repairs and replacement.

- Traffic congestion is the impact of psychological effects and reduce academic on students. It has greater effect social affairs participation on the community of social relation.
- The other effect of road traffic congestion is health and environmental problem on community. It is increasing air pollution and carbon dioxide emissions going to increased idling, acceleration and braking.
- It has led to an increase in accidents, which cause death, destruction of properties, permanent disability and injuries. The trip makers answered more than 90 percent of respondents agreed for this impact.
- As we can see from the analysis of one way mean analysis of variance the probability value is less than the alpha level. Based on the objective of the mean variance significant level at 0.05 or 5 percent is significant and its road traffic is the impact of socio-economic activities.
- The average travel speed of the vehicle during the morning and night time is 10.6 Km/hr. But during mid-day the average travel speed is 22.6 km/hr it increased relative to the peak period and still, it is congested. The total average of the speed of vehicles through the segment is 16.6 km/hr. Based on the highway capacity manual urban street speed criteria the level of service (LOS) is E based on highway capacity manual by average speed of urban street of LOS criteria. The average travel speed is decrease during the peak period but the average actual travel rate, delay rate, delay per traveler, travel time, travel time index, total segment delay, and delay ratio are increase. The total delay of road segment roads is 3850.61 PCU-hour.
- The total economic travel time cost of congestion can be considered based on the procedure of speed-flow curve. Hence, the total economic cost of congestion wasted from Megenagna to CMC Michael road segment is 42,897752.15 birr in the year of in 2017.

## 5.2 Recommendation

The amount of congestion costs seems to be systematically overestimated, especially when compared to other external effects, like environmental cost, Accident costs. Essential for any successful strategy to maximize the social benefits of transport and to minimize the costs of traffic congestion is a combination of efficient transport economy measures, sustainable road design, and intelligent traffic control.

In addressing the problem of traffic congestion, the respondents and various stakeholders gave a number of suggestions and recommendations to the respective authority.

- **Improving public transport**

Public transport has the potential to transport more people than individual cars for given amount of road space. The promotion of public transport remains a fundamentally important congestion management strategy. When public transport provides quality service, it can maintain a high level of access throughout urban areas with a drop in overall car usage. Since government must be increasing the amount of public transport and enterprise bus service.

- **Road Safety**

Safety on roads for pedestrian as well as for drivers is an important aspect of life. Before to build the road must be considering the first is safety for pedestrians and drivers especially disable persons. Without considering the road safety traffic injuries represent a leading and increasing contributor to regional to and global disease burden. However the government must be before construct the road to analyze and consider safety becomes first.

- **Discourage private cars**

A bus can be accommodate people as much as provided by many cars and occupy less space on roads. It will be terribly useful to cut back a load on the road by discouraging non-public car. It is possible to discourage people from the private car is very easy in low-income area and ultimately reduce traffic load and congestion. It is clearly that road space occupancy of bus is much lower as compared to cars and also the pollution caused by cars is more as compared to bus.

- **Avoiding poor Traffic management**

The poor traffic management is a result of malfunctioning of traffic light, absence of road signals, inadequate enforcement of laws (e.g illegal trade, construction works, etc.), low penalties

given to punish violators of traffic congestions, employment of few law enforcers for instance traffic police and lack of facilities to tow disable vehicles on the road.

Traffic management refers to the direction, control and supervision of all vehicular and pedestrian traffic around congested road. Good traffic management is key to achieving the goal of road traffic management for safe and efficient road network for urban congested road. This involves management and control of road signals, road spaces, parking spaces and road users. So that, the city of Addis Ababa traffic management as much as possible to responsible manage the road traffic congestion. The policy makers shall deduce relevant measures to minimize the costs of traffic congestion especially by implementing appropriate transportation system management that is optimizing system capacity operation.

- **Effect of on-street parking**

Effect of on street parking on road way capacity of the road is decreasing. Especially the width of the road is very narrow; it becomes the results of congestion and affects the travel time of people or employment. On-street parking must be a design consideration to ensure user convenience, and economic well-being of abutting properties. The government is must be parking lane width safe for vehicles and not effect on moving vehicles through the lane.

- **Pedestrian crossing**

Pedestrian crossing is the one of the impact of congestion well happened. Because the pedestrian moving on the crossing the driver stop some instant of time. During this time the queue formed and travel time lost. Most of peoples moving and crossing road is illegally means they have not used zebra crossing which is used arbitrary ways. The pedestrian crossing is design to be consideration of number of peoples where crossing, school zone, market, residential settlement, recreational area, governmental administrations etc. So that the government or traffic police to educate the people about road crossing law and give penalties when the unlawful persons.

- **Separate route for heavy loaded traffic**

Route must be separated according to different classes of vehicles, heavily loaded trucks should not be allowed into the main passenger and market area and separate route must be specified for these during peak hours.

#### Further Researchers

- Further research should be conducted to extend all aspects of this research, such as by collecting more data the whole city in order to improve results.
- During collecting travel speed and travel time modernized data collection method are better than manually method and to minimize the error and the work to simplify.
- In order to analysis total economic cost of congestion as much as possible including environment cost, fuel cost, accident cost.

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# Appendix

Table:4.15 Total traffic volume from Megenagna to CMC Michael road segment.

Time interval	Mid -block of road segment total traffic volume (PCU)		
	Megenagna - Gurd -shola	Gurd-shola - Civil service university	Civil service University - CMC Michael
	Monday	Wednesday	Friday
7:01 -7:15 AM	635	397	525
7:16-7:30	755	406	491
7:31 -7:45	744	530	608
7:46 -8:00	578	451	555
8:01-8:15	663	462	547
8:16-8:30	624	471	638
8:31-8:45	618	405	778
8:46-9:00	750	529	531
9:01-9:15	492	412	352
9:16-9:30	544	452	374
9:31 -9:45	472	211	506
9:46-10:00	547	407	397
10:01 - 10:15	452	319	449
10:16- 10:30	464	348	355
10:31 - 10:45	489	282	376
10:46- 11:00	512	364	407
11:01 - 11:15	421	360	401
11:16 - 11:30	611	388	360
11:31 - 11:45	598	282	473
11:46 - 12:00	432	285	384
12:01 - 12:15	608	420	307

12:16 - 12:30	513	286	335
12:31 - 12:45	516	359	379
12:46 - 1:00	560	376	466
1:01 - 1:15 PM	506	368	480
1:16 - 1:30	571	303	496
1:31- 1:45	553	354	417
1:46 - 2:00	474	305	496
2:01-2:15	643	399	464
2:16-2:30	460	247	467
2:31-2:45	586	341	393
2:46-3:00	547	386	431
3:01-3:15	549	318	346
3:16-3:30	616	399	461
3:31-3:45	645	431	343
3:45-4:00	467	338	298
4:01 -4:15	684	486	377
4:16 -4:30	497	358	427
4:31 -4:45	663	581	603
4:46 -5:00	721	601	652
5:01 -5:15	631	426	702
5:16 -5:30	702	579	914
5:31 -5:45	747	531	832
5:46 -6:00	938	664	797
Total volume	25786	17605	21380

Table:4.16 Average travel time of Megenagna to CMC Michael road segments

Time interval(min)	Average Travel Time(sec)		
	Megenagna -Gurd-shola (500m)	Gurd-shola -Civil service university (486m)	Civil service - CMC michael (460m)
7:01-7:15 AM	208.17	222.51	269.06
7:16-7:30	218.06	234.72	274.16
7:31 -7:45	234.92	252.84	256.25
7:46 -8:00	225.85	255.04	282.59
8:01-8:15	207.04	278.40	291.61
8:16-8:30	241.25	257.95	267.71
8:31-8:45	128.01	288.34	248.78
8:46-9:00	131.37	279.78	203.37
9:01-9:15	114.32	254.35	223.72
9:16-9:30	145.57	246.60	217.45
9:31 -9:45	83.54	231.77	194.52
9:46-10:00	81.18	173.62	188.19
10:01 - 10:15	78.38	70.17	87.38
10:16- 10:30	79.67	69.28	88.34
10:31 - 10:45	80.91	70.15	85.57
10:46- 11:00	80.19	70.64	85.27
11:01 - 11:15	79.29	73.38	87.73
11:16 - 11:30	79.79	71.31	88.73
11:31 - 11:45	80.69	71.12	87.97
11:46 - 12:00	80.41	71.28	87.19
12:01 - 12:15	79.36	72.13	88.78
12:16 - 12:30	79.47	67.13	91.49
12:31 - 12:45	78.41	71.74	91.37

12:46 - 1:00	76.94	69.46	86.11
1:01 - 1:15 PM	75.92	71.60	86.83
1:16 - 1:30	80.27	74.83	86.34
1:31- 1:45	77.71	73.49	89.07
1:46 - 2:00	74.46	71.12	84.77
2:01-2:15	74.47	73.70	88.01
2:16-2:30	74.50	73.00	85.49
2:31-2:45	75.67	73.16	89.77
2:46-3:00	77.97	70.24	87.15
3:01-3:15	77.33	71.59	90.45
3:16-3:30	75.59	75.75	90.77
3:31-3:45	72.47	71.76	86.47
3:45-4:00	74.44	73.96	89.97
4:01 -4:15	81.49	184.73	88.48
4:16 -4:30	79.54	174.96	87.63
4:31 -4:45	80.44	205.55	88.36
4:46 -5:00	81.36	210.84	85.34
5:01 -5:15	168.97	249.77	232.95
5:16 -5:30	242.25	279.05	243.43
5:31 -5:45	257.15	290.16	246.04
5:46 -6:00	257.25	290.00	285.83
Total	5132.01	6582.97	6386.45

Table:4.17 The average travel speed Megenagna to CMC Michael

Time interval(min)	Average Travel Speed(km/hrs)		
	Megenagna–Gurd shola (500m)	Gurd-shola-Civil service university (486m)	Civil-Service-CMC Michael (460m)
7:01 -7:15 AM	8.6	7.9	6.2
7:16-7:30	8.3	7.5	6.0
7:31 -7:45	7.7	6.9	6.5
7:46 -8:00	8.0	6.9	5.9
8:01-8:15	8.7	6.3	5.7
8:16-8:30	7.5	6.8	6.2
8:31-8:45	14.1	6.1	6.7
8:46-9:00	13.7	6.3	8.1
9:01-9:15	15.7	6.9	7.4
9:16-9:30	12.4	7.1	7.6
9:31 -9:45	21.5	7.5	8.5
9:46-10:00	22.2	10.1	8.8
10:01 - 10:15	23.0	24.9	19.0
10:16- 10:30	22.6	25.3	18.7
10:31 - 10:45	22.2	24.9	19.4
10:46- 11:00	22.4	24.8	19.4
11:01 - 11:15	22.7	23.8	18.9
11:16 - 11:30	22.6	24.5	18.7
11:31 - 11:45	22.3	24.6	18.8
11:46 - 12:00	22.4	24.5	19.0
12:01 - 12:15	22.7	24.3	18.7

12:16 - 12:30	22.7	26.1	18.1
12:31 - 12:45	23.0	24.4	18.1
12:46 - 1:00	23.4	25.2	19.2
1:01 - 1:15 PM	23.7	24.4	19.1
1:16 - 1:30	22.4	23.4	19.2
1:31- 1:45	23.2	23.8	18.6
1:46 - 2:00	24.2	24.6	19.5
2:01-2:15	24.2	23.7	18.8
2:16-2:30	24.2	24.0	19.4
2:31-2:45	23.8	23.9	18.4
2:46-3:00	23.1	24.9	19.0
3:01-3:15	23.3	24.4	18.3
3:16-3:30	23.8	23.1	18.2
3:31-3:45	24.8	24.4	19.2
3:45-4:00	24.2	23.7	18.4
4:01 -4:15	22.1	9.5	18.7
4:16 -4:30	22.6	10.0	18.9
4:31 -4:45	22.4	8.5	18.7
4:46 -5:00	22.1	8.3	19.4
5:01 -5:15	10.7	7.0	7.1
5:16 -5:30	7.4	6.3	6.8
5:31 -5:45	7.0	6.0	6.7
5:46 -6:00	7.0	6.0	5.8

Table:4.18 vehicle occupancy(person/vehicle)

Time interval	AUTO(5)	Avoc	4WD (5)	Avoc	Small bus(12)	Avoc	minibus(14)	Avoc	mid-isuzu(24)	Avoc
7:01 -7:15 AM	142	1.9	48	0.6	46	1.5	48	1.8	5	0.3
7:16-7:30	178	2.0	66	0.7	64	1.7	33	1.0	7	0.4
7:31 -7:45	128	1.5	97	1.1	49	1.3	51	1.6	0	0.0
7:46 -8:00	144	2.1	41	0.6	36	1.3	49	2.0	6	0.4
8:01-8:15	184	2.1	77	0.9	26	0.7	37	1.2	4	0.2
8:16-8:30	147	1.8	112	1.4	28	0.8	28	1.0	3	0.2
8:31-8:45	98	1.4	88	1.2	40	1.3	51	2.0	6	0.4
8:46-9:00	174	1.7	189	1.9	24	0.6	42	1.2	9	0.4
9:01-9:15	96	1.6	78	1.3	10	0.4	63	3.0	0	0.0
9:16-9:30	77	1.1	112	1.7	33	1.2	34	1.4	4	0.3
9:31 -9:45	47	0.9	77	1.5	44	2.0	47	2.5	2	0.2
9:46-10:00	104	1.6	88	1.3	24	0.9	41	1.7	5	0.4
10:01 - 10:15	88	1.7	33	0.7	33	1.6	29	1.6	0	0.0
10:16- 10:30	74	1.4	44	0.8	44	2.0	33	1.8	2	0.2
10:31 - 10:45	123	2.0	69	1.1	28	1.1	38	1.7	5	0.4
10:46- 11:00	126	2.1	48	0.8	49	1.9	19	0.9	0	0.0
11:01 - 11:15	81	1.7	36	0.8	33	1.7	11	0.7	7	0.7
11:16 - 11:30	140	1.9	77	1.0	60	2.0	31	1.2	6	0.4
11:31 - 11:45	48	0.8	89	1.4	47	1.8	49	2.2	6	0.5
11:46 - 12:00	74	1.5	33	0.7	40	2.0	21	1.2	5	0.5
12:01 - 12:15	139	2.0	28	0.4	55	1.9	38	1.5	1	0.1
12:16 - 12:30	48	0.8	81	1.4	40	1.7	44	2.1	6	0.5
12:31 - 12:45	171	2.5	49	0.7	38	1.3	12	0.5	3	0.2
12:46 - 1:00	123	1.8	68	1.0	41	1.5	43	1.8	5	0.4
1:01 - 1:15 PM	91	1.6	47	0.8	56	2.4	27	1.3	2	0.2
1:16 - 1:30	78	1.3	66	1.1	52	2.0	43	1.9	4	0.3
1:31- 1:45	123	1.9	44	0.7	36	1.3	33	1.4	4	0.3
1:46 - 2:00	78	1.5	44	0.8	38	1.7	32	1.7	4	0.4
2:01-2:15	148	2.0	39	0.5	56	1.8	44	1.6	0	0.0
2:16-2:30	89	1.8	30	0.6	23	1.1	55	3.1	4	0.4
2:31-2:45	141	2.0	49	0.7	48	1.7	39	1.6	2	0.1
2:46-3:00	66	1.1	44	0.8	63	2.6	41	2.0	2	0.2
3:01-3:15	89	1.5	49	0.8	44	1.8	50	2.4	3	0.2
3:16-3:30	103	1.5	70	1.0	61	2.1	44	1.8	2	0.1

3:31-3:45	117	1.6	56	0.8	78	2.6	41	1.6	3	0.2
3:45-4:00	129	2.3	42	0.7	33	1.4	29	1.4	3	0.3
4:01 -4:15	189	2.3	43	0.5	78	2.3	36	1.2	2	0.1
4:16 -4:30	147	2.4	44	0.7	29	1.1	38	1.7	2	0.2
4:31 -4:45	236	2.6	78	0.9	44	1.2	33	1.0	3	0.2
4:46 -5:00	201	2.3	65	0.7	67	1.8	44	1.4	0	0.0
5:01 -5:15	117	1.6	88	1.2	31	1.0	63	2.4	4	0.3
5:16 -5:30	187	2.2	67	0.8	60	1.7	38	1.2	7	0.4
5:31 -5:45	129	1.6	66	0.8	67	1.9	44	1.5	6	0.3
5:46 -6:00	298	2.4	87	0.7	49	1.0	64	1.5	5	0.2

Time interval	sheger(39)	Avoc	higer(27)	Avoc	public bus(45)	Avoc	Mid.bus(45 seats)	Avoc	L.Anbessa bus(60seats)	Avoc
7:01 -7:15 AM	7	0.7	9	0.6	4	0.5	6	0.7	8	1.3
7:16-7:30	14	1.2	13	0.8	6	0.6	11	1.1	11	1.5
7:31 -7:45	11	1.0	6	0.4	7	0.7	9	0.9	8	1.1
7:46 -8:00	9	1.0	8	0.6	3	0.4	4	0.5	9	1.6
8:01-8:15	6	0.5	7	0.4	4	0.4	8	0.8	11	1.5
8:16-8:30	12	1.2	14	0.9	8	0.9	7	0.8	2	0.3
8:31-8:45	7	0.8	14	1.0	5	0.6	3	0.4	7	1.2
8:46-9:00	21	1.6	12	0.6	4	0.4	8	0.7	9	1.1
9:01-9:15	10	1.3	4	0.4	0	0.0	9	1.4	4	0.8
9:16-9:30	9	1.0	7	0.6	7	0.9	8	1.1	4	0.7
9:31 -9:45	3	0.4	4	0.4	1	0.2	9	1.6	11	2.5
9:46-10:00	2	0.2	7	0.6	2	0.3	27	3.7	3	0.5
10:01 - 10:15	13	2.0	8	0.9	1	0.2	9	1.6	7	1.7
10:16- 10:30	6	0.9	3	0.3	1	0.2	5	0.9	10	2.3
10:31 - 10:45	9	1.1	6	0.5	3	0.4	4	0.6	7	1.4
10:46- 11:00	4	0.5	11	1.0	4	0.6	5	0.7	9	1.8
11:01 - 11:15	11	1.8	14	1.6	0	0.0	6	1.2	8	2.1
11:16 - 11:30	12	1.3	8	0.6	0	0.0	3	0.4	13	2.1
11:31 - 11:45	9	1.1	11	0.9	0	0.0	8	1.1	9	1.7
11:46 - 12:00	6	1.0	9	1.0	0	0.0	6	1.1	11	2.8
12:01 - 12:15	10	1.1	15	1.2	0	0.0	11	1.4	10	1.7
12:16 - 12:30	8	1.1	9	0.8	0	0.0	7	1.1	7	1.5
12:31 - 12:45	6	0.7	9	0.7	0	0.0	10	1.3	4	0.7

12:46 - 1:00	9	1.1	9	0.7	9	1.2	3	0.4	5	0.9
1:01 - 1:15 PM	13	1.8	11	1.0	2	0.3	9	1.4	3	0.6
1:16 - 1:30	10	1.3	7	0.6	9	1.3	4	0.6	4	0.8
1:31- 1:45	8	1.0	8	0.7	7	1.0	3	0.4	6	1.1
1:46 - 2:00	7	1.0	11	1.1	4	0.7	8	1.4	6	1.4
2:01-2:15	10	1.0	9	0.6	7	0.8	7	0.8	7	1.1
2:16-2:30	6	0.9	7	0.8	2	0.4	4	0.7	3	0.7
2:31-2:45	8	0.9	10	0.8	2	0.3	11	1.4	8	1.4
2:46-3:00	6	0.8	13	1.2	2	0.3	4	0.6	9	1.9
3:01-3:15	7	0.9	14	1.3	4	0.6	8	1.2	4	0.8
3:16-3:30	6	0.7	9	0.7	3	0.4	3	0.4	10	1.7
3:31-3:45	2	0.2	9	0.7	3	0.4	9	1.1	3	0.5
3:45-4:00	7	1.0	8	0.8	1	0.2	8	1.3	6	1.3
4:01 -4:15	8	0.8	10	0.7	1	0.1	9	1.0	1	0.1
4:16 -4:30	12	1.5	7	0.6	1	0.1	4	0.6	9	1.7
4:31 -4:45	9	0.8	5	0.3	2	0.2	5	0.5	4	0.5
4:46 -5:00	7	0.6	12	0.7	7	0.7	10	1.0	8	1.1
5:01 -5:15	9	0.9	7	0.5	9	1.1	4	0.5	9	1.5
5:16 -5:30	2	0.2	13	0.8	11	1.2	9	0.9	6	0.8
5:31 -5:45	9	0.8	9	0.6	12	1.3	11	1.2	11	1.6
5:46 -6:00	9	0.6	10	0.4	13	1.0	8	0.6	7	0.7

Table:4.19 Average Vehicle occupancy (Person per vehicle)

Road segment	Megenagna -Gurd-shola		Gurd-shola –Civil.S.U		CSU - CMC Michael		
	Veh. Occu.	Time interval	Veh. Occu	Veh. Occu	Veh. Occu	Veh. Occu	
7:01 -7:15 AM	10.0	12:31 - 12:45	8.6	8.1	10.0	8.5	9.5
7:16-7:30	11.1	12:46 - 1:00	10.8	9.1	9.2	9.8	11.2
7:31 -7:45	9.6	1:01 - 1:15 PM	11.5	10.0	11.3	8.5	10.7
7:46 -8:00	10.6	1:16 - 1:30	11.1	10.9	9.4	9.8	9.3
8:01-8:15	9.0	1:31- 1:45	9.8	10.6	9.3	9.5	10.3
8:16-8:30	9.3	1:46 - 2:00	11.6	9.0	11.0	8.9	10.2
8:31-8:45	10.2	2:01-2:15	10.4	11.0	8.0	9.4	9.6
8:46-9:00	10.1	2:16-2:30	10.4	10.8	9.3	13.2	10.9
9:01-9:15	10.1	2:31-2:45	10.8	10.6	7.9	12.2	9.2
9:16-9:30	10.1	2:46-3:00	11.5	10.8	12.1	10.6	8.6
9:31 -9:45	12.2	3:01-3:15	11.6	5.8	11.6	9.5	11.6
9:46-10:00	11.2	3:16-3:30	10.4	9.0	7.6	9.8	12.1
10:01 - 10:15	11.9	3:31-3:45	9.8	12.5	9.1	9.4	9.3
10:16- 10:30	10.7	3:45-4:00	10.5	10.1	9.4	13.0	12.4
10:31 - 10:45	10.4	4:01 -4:15	9.1	8.5	9.0	9.7	11.3
10:46- 11:00	10.2	4:16 -4:30	10.6	11.2	8.1	8.5	11.9
11:01 - 11:15	12.3	4:31 -4:45	8.2	14.9	10.5	10.2	10.8
11:16 - 11:30	10.8	4:46 -5:00	10.4	8.4	11.1	10.5	10.2
11:31 - 11:45	11.4	5:01 -5:15	10.9	10.0	8.6	11.7	10.1
11:46 - 12:00	11.9	5:16 -5:30	10.2	9.5	11.5	12.1	9.7
12:01 - 12:15	11.4	5:31 -5:45	11.7	10.2	12.2	10.7	9.3
12:16 - 12:30	11.0	5:46 -6:00	9.0	9.4	8.6	12.0	9.7

Table: 4.20 Congestion Analysis of delay from Megenagna to Gurd shola

Time interval(mi n)	Delay(min)	Actual Trvel rate(min/k m)	Delay rate(min/k m)	Delay ratio	Delay per Traveler(A nnuual hrs)	T.Time(per son-hours)	TTI	T.Delay(per son-min)
7:01 -7:15 AM	2.80	6.94	5.6	0.81	11.68	312.6	5.2	15150.78
7:16-7:30	2.97	7.27	5.9	0.82	12.37	450.2	5.5	22056.43
7:31 -7:45	3.25	7.83	6.5	0.83	13.54	375.8	5.9	18708.87
7:46 -8:00	3.10	7.53	6.2	0.82	12.91	343.6	5.7	16966.03
8:01-8:15	2.78	6.90	5.6	0.81	11.60	277.6	5.2	13436.68
8:16-8:30	3.35	8.04	6.7	0.83	13.98	336.1	6.0	16823.00
8:31-8:45	1.47	4.27	2.9	0.69	6.11	196.6	3.2	8108.97
8:46-9:00	1.52	4.38	3.0	0.70	6.34	263.2	3.3	10982.51
9:01-9:15	1.24	3.81	2.5	0.65	5.16	140.6	2.9	5482.89
9:16-9:30	1.76	4.85	3.5	0.73	7.33	192.5	3.6	8376.31
9:31 -9:45	0.73	2.78	1.5	0.52	3.02	125.2	2.1	3914.46
9:46-10:00	0.69	2.71	1.4	0.51	2.86	124.3	2.0	3783.49
10:01 - 10:15	0.64	2.61	1.3	0.49	2.67	101.1	2.0	2970.11
10:16- 10:30	0.66	2.66	1.3	0.50	2.75	92.7	2.0	2768.23
10:31 - 10:45	0.68	2.70	1.4	0.51	2.84	107.1	2.0	3247.82
10:46- 11:00	0.67	2.67	1.3	0.50	2.79	100.7	2.0	3027.26
11:01 - 11:15	0.65	2.64	1.3	0.50	2.73	99.1	2.0	2946.77
11:16 - 11:30	0.66	2.66	1.3	0.50	2.76	136.4	2.0	4082.45
11:31 - 11:45	0.68	2.69	1.4	0.51	2.83	129.3	2.0	3913.40
11:46 - 12:00	0.67	2.68	1.4	0.50	2.81	98.2	2.0	2960.97
12:01 - 12:15	0.66	2.65	1.3	0.50	2.73	135.7	2.0	4038.90
12:16 - 12:30	0.66	2.65	1.3	0.50	2.74	109.1	2.0	3251.77
12:31 - 12:45	0.64	2.61	1.3	0.49	2.67	82.7	2.0	2431.42
12:46 - 1:00	0.62	2.56	1.2	0.48	2.57	120.1	1.9	3459.92
1:01 - 1:15 PM	0.60	2.53	1.2	0.47	2.49	113.3	1.9	3217.12
1:16 - 1:30	0.67	2.68	1.3	0.50	2.80	122.8	2.0	3696.81
1:31- 1:45	0.63	2.59	1.3	0.49	2.62	94.3	1.9	2745.77
1:46 - 2:00	0.57	2.48	1.2	0.46	2.39	100.2	1.9	2783.30
2:01-2:15	0.57	2.48	1.2	0.46	2.39	119.7	1.9	3323.83
2:16-2:30	0.58	2.48	1.2	0.46	2.40	84.4	1.9	2344.00
2:31-2:45	0.59	2.52	1.2	0.47	2.48	120.7	1.9	3413.73
2:46-3:00	0.63	2.60	1.3	0.49	2.64	119.0	2.0	3477.98
3:01-3:15	0.62	2.58	1.2	0.48	2.59	122.4	1.9	3544.99
3:16-3:30	0.59	2.52	1.2	0.47	2.47	116.7	1.9	3296.56
3:31-3:45	0.54	2.42	1.1	0.45	2.26	110.0	1.8	2956.35
3:45-4:00	0.57	2.48	1.2	0.46	2.39	92.0	1.9	2553.05
4:01 -4:15	0.69	2.72	1.4	0.51	2.88	125.9	2.0	3847.31

4:16 -4:30	0.66	2.65	1.3	0.50	2.75	108.5	2.0	3235.33
4:31 -4:45	0.67	2.68	1.4	0.50	2.81	107.7	2.0	3248.38
4:46 -5:00	0.69	2.71	1.4	0.51	2.87	159.0	2.0	4848.15
5:01 -5:15	2.15	5.63	4.3	0.76	8.96	288.5	4.2	13212.69
5:16 -5:30	3.37	8.08	6.7	0.84	14.05	440.6	6.1	22073.00
5:31 -5:45	3.62	8.57	7.2	0.84	15.08	538.5	6.4	27286.26
5:46 -6:00	3.62	8.58	7.2	0.84	15.09	532.0	6.4	26958.62
Total	56.20							324952.67

Table: 4.21 Congestion analysis of delay from Gurd shola to Civil service University

Time interval(m in)	Delay(min)	Travel rate(min/km)	Delay rate(min/km)	Delay ratio	Delay per Traveler(Annual hrs)	T.Time(person-hours)	TTI	T.Delay(person-min)
7:01 -7:15 AM	3.0	7.6	6.3	0.83	12.67	165.0	5.7	8119.1
7:16-7:30	3.2	8.0	6.7	0.83	13.52	217.2	6.1	10810.7
7:31 -7:45	3.5	8.7	7.3	0.85	14.78	296.5	6.5	14975.7
7:46 -8:00	3.6	8.7	7.4	0.85	14.93	332.3	6.6	16810.4
8:01-8:15	4.0	9.5	8.2	0.86	16.56	327.2	7.2	16811.1
8:16-8:30	3.6	8.8	7.5	0.85	15.14	267.6	6.7	13567.0
8:31-8:45	4.1	9.9	8.6	0.87	17.25	305.5	7.4	15785.7
8:46-9:00	4.0	9.6	8.3	0.86	16.65	404.4	7.2	20792.4
9:01-9:15	3.6	8.7	7.4	0.85	14.89	283.7	6.6	14345.3
9:16-9:30	3.4	8.5	7.1	0.84	14.35	267.7	6.4	13458.3
9:31 -9:45	3.2	7.9	6.6	0.83	13.32	69.7	6.0	3460.2
9:46-10:00	2.2	6.0	4.6	0.78	9.28	153.6	4.5	7093.0
10:01 - 10:15	0.5	2.4	1.1	0.45	2.10	65.9	1.8	1700.0
10:16- 10:30	0.5	2.4	1.0	0.44	2.03	54.0	1.8	1369.5
10:31 - 10:45	0.5	2.4	1.1	0.45	2.09	41.6	1.8	1072.6
10:46- 11:00	0.5	2.4	1.1	0.45	2.13	70.3	1.8	1828.7
11:01 - 11:15	0.6	2.5	1.2	0.47	2.32	98.1	1.9	2678.6
11:16 - 11:30	0.5	2.4	1.1	0.46	2.17	56.0	1.8	1475.5
11:31 - 11:45	0.5	2.4	1.1	0.45	2.16	47.7	1.8	1252.1
11:46 - 12:00	0.5	2.4	1.1	0.46	2.17	50.4	1.8	1327.7
12:01 - 12:15	0.5	2.5	1.1	0.46	2.23	77.4	1.9	2069.7
12:16 - 12:30	0.5	2.3	1.0	0.42	1.88	41.8	1.7	1014.6
12:31 - 12:45	0.5	2.5	1.1	0.46	2.20	65.4	1.8	1736.6
12:46 - 1:00	0.5	2.4	1.1	0.44	2.05	57.3	1.8	1457.0
1:01 - 1:15 PM	0.5	2.5	1.1	0.46	2.19	75.4	1.8	1996.9
1:16 - 1:30	0.6	2.6	1.2	0.48	2.42	54.2	1.9	1514.3
1:31- 1:45	0.6	2.5	1.2	0.47	2.33	56.0	1.9	1532.0
1:46 - 2:00	0.5	2.4	1.1	0.45	2.16	61.3	1.8	1610.0
2:01-2:15	0.6	2.5	1.2	0.47	2.34	60.1	1.9	1650.0
2:16-2:30	0.5	2.5	1.2	0.47	2.29	38.1	1.9	1033.6
2:31-2:45	0.6	2.5	1.2	0.47	2.30	50.4	1.9	1369.6
2:46-3:00	0.5	2.4	1.1	0.45	2.10	81.4	1.8	2101.8
3:01-3:15	0.5	2.5	1.1	0.46	2.19	65.8	1.8	1742.9
3:16-3:30	0.6	2.6	1.3	0.49	2.48	53.5	2.0	1514.9
3:31-3:45	0.5	2.5	1.1	0.46	2.21	60.9	1.9	1616.0
3:45-4:00	0.6	2.5	1.2	0.48	2.36	57.4	1.9	1582.4
4:01 -4:15	2.4	6.3	5.0	0.79	10.05	202.2	4.8	9504.9

4:16 -4:30	2.2	6.0	4.7	0.78	9.37	125.6	4.5	5811.6
4:31 -4:45	2.8	7.0	5.7	0.81	11.50	315.6	5.3	15251.3
4:46 -5:00	2.8	7.2	5.9	0.82	11.86	342.9	5.4	16672.6
5:01 -5:15	3.5	8.6	7.2	0.84	14.57	211.3	6.4	10649.7
5:16 -5:30	4.0	9.6	8.2	0.86	16.60	465.8	7.2	23942.9
5:31 -5:45	4.2	10.0	8.6	0.87	17.37	422.8	7.5	21868.4
5:46 -6:00	4.2	9.9	8.6	0.87	17.36	393.3	7.5	20341.6
Total sum					334.93			318318.7

Table: 4.22 Congestion Analysis of delay from Civil service University to CMC Michael

Time interval( min)	Delay(mi n)	Actual Trvel rate(min/ km)	Delay rate(min/ km)	Delay ratio	Delay per Traveler( Annual hrs)	T. Time(p erson- hours)	TTI	T.Delay(p erson- min)
7:01 -7:15 AM	3.8	9.7	8.4	0.86	15.9	304.8	7.3	15568.8
7:16-7:30	3.9	9.9	8.6	0.87	16.3	317.2	7.5	16257.5
7:31 -7:45	3.6	9.3	8.0	0.86	15.0	309.9	7.0	15689.2
7:46 -8:00	4.0	10.2	8.9	0.87	16.8	412.9	7.7	21265.1
8:01-8:15	4.2	10.6	9.2	0.87	17.5	360.7	7.9	18673.5
8:16-8:30	3.8	9.7	8.4	0.86	15.8	360.3	7.3	18387.4
8:31-8:45	3.5	9.0	7.7	0.85	14.5	388.6	6.8	19565.7
8:46-9:00	2.7	7.4	6.0	0.82	11.3	363.0	5.5	17497.2
9:01-9:15	3.1	8.1	6.8	0.84	12.8	251.4	6.1	12386.9
9:16-9:30	3.0	7.9	6.5	0.83	12.3	218.0	5.9	10672.4
9:31 -9:45	2.6	7.0	5.7	0.81	10.7	245.8	5.3	11713.2
9:46-10:00	2.5	6.8	5.5	0.80	10.3	181.1	5.1	8554.9
10:01 - 10:15	0.8	3.2	1.8	0.58	3.3	92.5	2.4	3008.2
10:16- 10:30	0.8	3.2	1.9	0.58	3.4	99.3	2.4	3259.5
10:31 - 10:45	0.8	3.1	1.8	0.57	3.2	85.9	2.3	2744.9
10:46- 11:00	0.8	3.1	1.8	0.57	3.1	68.2	2.3	2173.4
11:01 - 11:15	0.8	3.2	1.8	0.58	3.3	97.1	2.4	3169.2
11:16 - 11:30	0.8	3.2	1.9	0.59	3.4	88.2	2.4	2905.5
11:31 - 11:45	0.8	3.2	1.9	0.58	3.3	119.2	2.4	3899.1
11:46 - 12:00	0.8	3.2	1.8	0.58	3.3	104.4	2.4	3391.4
12:01 - 12:15	0.8	3.2	1.9	0.59	3.4	76.8	2.4	2532.5
12:16 - 12:30	0.9	3.3	2.0	0.60	3.6	95.4	2.5	3220.3
12:31 - 12:45	0.9	3.3	2.0	0.60	3.6	79.4	2.5	2679.2
12:46 - 1:00	0.8	3.1	1.8	0.57	3.2	116.5	2.3	3744.1
1:01 - 1:15 PM	0.8	3.1	1.8	0.58	3.3	107.6	2.4	3481.7
1:16 - 1:30	0.8	3.1	1.8	0.57	3.2	102.4	2.4	3298.0
1:31- 1:45	0.8	3.2	1.9	0.59	3.4	97.4	2.4	3219.8
1:46 - 2:00	0.7	3.1	1.7	0.57	3.1	111.5	2.3	3533.1
2:01-2:15	0.8	3.2	1.9	0.58	3.3	96.5	2.4	3159.0
2:16-2:30	0.8	3.1	1.8	0.57	3.2	115.7	2.3	3693.7
2:31-2:45	0.8	3.3	1.9	0.59	3.5	78.0	2.4	2596.2
2:46-3:00	0.8	3.2	1.8	0.58	3.3	78.9	2.4	2560.1
3:01-3:15	0.8	3.3	1.9	0.59	3.5	93.0	2.5	3111.6
3:16-3:30	0.8	3.3	2.0	0.60	3.5	123.0	2.5	4126.3
3:31-3:45	0.8	3.1	1.8	0.58	3.2	64.5	2.4	2078.9
3:45-4:00	0.8	3.3	1.9	0.59	3.5	86.0	2.5	2865.7
4:01 -4:15	0.8	3.2	1.9	0.59	3.4	94.2	2.4	3098.3
4:16 -4:30	0.8	3.2	1.8	0.58	3.3	103.1	2.4	3363.9

4:31 -4:45	0.8	3.2	1.9	0.58	3.4	143.4	2.4	4707.8
4:46 -5:00	0.8	3.1	1.8	0.57	3.1	141.4	2.3	4508.2
5:01 -5:15	3.2	8.4	7.1	0.84	13.4	409.4	6.3	20346.2
5:16 -5:30	3.4	8.8	7.5	0.85	14.1	550.6	6.6	27608.4
5:31 -5:45	3.4	8.9	7.6	0.85	14.3	453.5	6.7	22786.5
5:46 -6:00	4.1	10.4	9.0	0.87	17.1	542.0	7.8	27970.6
Total sum								375073.4

Table:4.23 Total Economic Cost of Congestion from Megenagna to Gurd – Shola

Actual Average speed of PC(Km/hr)	Traffic hourly volume(veh/hr)	Economic cost of congestion(Birr/hr)
8.65	375	440123.55
8.25	447	530289.11
7.66	438	527989.52
7.97	339	405279.69
8.69	430	504018.85
7.46	400	484776.40
14.06	361	360590.03
13.70	510	515330.32
15.75	298	281458.97
12.36	335	352964.70
21.55	261	197625.50
22.17	330	243191.81
22.96	252	179279.60
22.59	263	190243.12
22.25	308	226263.17
22.45	306	222800.60
22.70	232	167027.20
22.56	369	267330.63
22.31	318	232960.31
22.39	239	174497.82
22.68	346	249321.38
22.65	289	208519.83
22.96	344	244805.70
23.40	334	232962.57
23.71	283	194526.99
22.42	310	225945.33
23.16	324	228425.12
24.18	265	178166.91
24.17	376	252833.15
24.16	251	168876.85
23.79	348	238319.21
23.09	289	204461.94
23.28	296	207594.09
23.81	347	237359.39
24.84	356	231748.46

24.18	285	191552.51
22.09	410	303256.83
22.63	312	225321.38
22.38	450	328665.58
22.12	441	325687.31
10.65	372	412510.59
7.43	430	521564.00
7.00	414	507910.22
7.00	610	748426.34
Total sum (ETB)		13372802.56

Table:4.24 Total Economic Cost of Congestion from Gurd – Shola to Civil service university

Actual Average speed of (Km/hr)	Traffic hourly volume(veh/hr)	Economic cost of congestion(Birr/hr)
7.86	332	398055.88
7.45	339	410925.95
6.92	438	538484.60
6.86	383	471604.49
6.28	419	523719.34
6.78	387	477496.75
6.07	329	413528.96
6.25	468	585436.46
6.88	329	404915.01
7.09	363	444228.14
7.55	168	203130.67
10.08	319	359669.49
24.93	260	168447.20
25.25	275	175319.79
24.94	226	146351.81
24.77	282	184216.42
23.84	274	187144.86
24.53	323	213421.36
24.60	225	148191.79
24.54	229	151229.95
24.26	336	225036.49
26.06	225	137548.76
24.39	314	208969.80
25.19	301	192512.73
24.43	279	185245.97
23.38	260	181482.04
23.81	296	202534.47
24.60	247	162681.65
23.74	318	218277.82
23.97	210	142590.62
23.92	279	189916.37
24.91	283	183552.31
24.44	271	179897.53
23.10	310	219224.80
24.38	343	228320.36

23.66	279	192248.92
9.47	400	458822.21
10.00	299	337861.42
8.51	487	573693.92
8.30	492	582978.09
7.00	351	430561.77
6.27	469	586437.34
6.03	426	535973.86
6.03	534	671796.70
Total sum (ETB)		13833684.86

Table:4.25 Total Economic Cost of Congestion from Civil service university to CMC Michael

Actual Average speed of PC(Km/hr)	Traffic hourly volume(veh/hr)	Economic cost of congestion(Birr/hr)
6.15	410	514187.69
6.04	355	446525.51
6.46	450	559882.22
5.86	421	531988.05
5.68	405	514142.11
6.19	470	588965.78
6.66	546	675905.92
8.14	342	406958.97
7.40	243	294963.82
7.62	268	323465.98
8.51	387	455876.38
8.80	288	336593.05
18.95	334	280890.73
18.75	227	192409.35
19.35	292	241773.24
19.42	307	253520.43
18.88	306	258081.40
18.66	266	226166.83
18.83	316	267032.09
18.99	254	213265.19
18.65	223	189684.73
18.10	224	194528.32
18.12	269	233406.37
19.23	330	274532.40
19.07	331	277085.01
19.18	373	310935.16
18.59	302	257470.55
19.54	360	295964.36
18.82	337	284882.62
19.37	337	278854.49
18.45	285	244318.81
19.00	337	282860.31
18.31	238	205092.81
18.24	296	255681.19
19.15	242	201954.55

18.41	202	173427.08
18.72	260	220628.67
18.90	273	230059.23
18.74	426	361132.08
19.40	473	390867.26
7.11	509	622666.64
6.80	676	833642.81
6.73	613	757376.31
5.79	578	731618.21
Total sum (ETB)		15691264.73

**Questionnaire on The Socio-Economic Impact of Road Traffic Congestion in Addis Ababa city in case of Megenagna to CMC Road Segment.**

Name of the Organization\_\_\_\_\_

Dear Respondent; Thank you for taking part in this study. I am Sileshi setito from Addis Ababa university institute of technology department of Civil and Environmental Engineering. May I wish to notify you that this questionnaire has the aim of gathering information about the study titled “The Socio-Economic Impact of Road Traffic Congestion in Addis Ababa city in case of Megenagna to CMC st. Michael ” This is purely an academic study, which is being conducted as a partial fulfillment for the award of degree on Masters of Science in Road and Transport Engineering. Through this information, the researcher will be able to assess and document the Social economic impact of road traffic congestion in Addis Ababa city. It should be noted that all information obtained will be treated very confidentially and used for intended purpose only. Please feel free to answer the questions according to your experience and your personal understanding.

Your sincerely!!!

Sileshi Setito

09 20 23 48 19

## **I. INSTRUCTION**

Don't write your name. Please circle in the given alternative choice as per requirement of the statement.

1. **Sex:** A. Male                      B. Female

### **2. Age**

A) 18 - 25 yrs

B) 26 – 35yrs

C) 36 – 45 yrs

D) 46– 55 yrs

E) Above 55

### **3. Educational level**

A. Primary level

B. Secondary level

C. Diploma

D. Degree

E. Masters and above

### **4. Type of occupation**

A. public employed

B. private-employed

C. self employed

D. Student

### **5. Position**

A. Management level

B. Middle level / line manager

C. Operational level

D. Student

## **II. Instruction**

Read carefully each questions and, circle the best answer based on your experience to appropriate the questions. Each questions only one answer.

1. Congestion is the impact of social, economic and political problems which more our life very hard and rough.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

2. Delay which may results late arrival for employment, meeting and education, resulting in lost business, disciplinary action and other personal losses.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

3. Inability to forecast travel time accurately, leading to drivers allocating more time to travel “just in case” and less time on production activities.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

4. Due to congestion, wasted fuel increasing air pollution and carbon dioxide emissions owing to increased idling, acceleration and braking.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

5. Traffic congestion is the wear and tear on vehicles as a result of idling in traffic and frequent acceleration and braking, leading to more frequent repairs and replacement.

- |                   |                        |
|-------------------|------------------------|
| 1. Strongly agree | 4. Disagree            |
| 2. Agree          | 5. . Strongly disagree |
| 3. Neutral        |                        |

6. Traffic congestion impact of resulting is wasting time of motorist and passengers.

- |                   |                        |
|-------------------|------------------------|
| 1. Strongly agree | 4. Disagree            |
| 2. Agree          | 5. . Strongly disagree |
| 3. Neutral        |                        |

7. Traffic congestion is the impact of psychological effects and reduce academic on students.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

8. It has greater effect social affairs participation on the community social relation.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

9. It has health and environmental problem on community.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

10. Road traffic congestion has led to an increase in accidents, which cause death, destruction of properties, permanent disability and injuries.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

11. It has the result of extra transportation cost on community.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

12. Due to this result increasing vehicle operating cost for different purpose.

- |                   |                      |
|-------------------|----------------------|
| 1. Strongly agree | 4. Disagree          |
| 2. Agree          | 5. Strongly disagree |
| 3. Neutral        |                      |

### **Part III**

- 1) Write down the effect of congestion on your suggestion?
- 2) List down the cause of the impact during travel to work and home?
- 3) What about the environmental effect on your concept?
- 4) List down the problem of road traffic congestion?

**በአዲስ አበባ ዩኒቨርሲቲ የሲቪል ምህንድስና ትምህርት ክፍል ተማሪ የድህረ ምረቃት ትምህርት**

**ፕሮግራም ማሟያ (ግብአት) የቀረቡ የናሙና መጠይቆች**

**ውል የመጠይቁ መላሾች**

- ይህ መጠይቅ በአዲስ አበባ ዩኒቨርሲቲ ተማሪ ለድህረ ምረቃ የትምህርት ፕሮግራም የመመረቂያ ጽሁፍ ማሟያ (የግብአት) እንዲሆን የተዘጋጀ ሲሆን ይህ መጠይቅ “Assessing socio-economic impact of road traffic congestion In Addis Ababa City in case of Meganagna to CMC St. Micael” በሚል ርዕስ እየሰራሁ እገኛለሁ። ስለሆነም ይህ መጠይቅ የተዘጋጀው ለማስተርስ ዲግሪ መመረቂያ ማሟያ ሲሆን መጠይቁ በአዲስ አበባ ከተማ ከመገናኛ እስከ ሲ.ኤም.ሲ. ሚካኤል የመንገድ ትራፊክ ፍሰት መጨመር በማሕበራዊና በኢኮኖሚያዊ እንቅስቃሴዎች የሚያመጣው ተጽእኖ ለማጥናት ለሚሰራ ጥናታዊ ጽሑፍ (RESEARCH) ነው።
- ለጥናታዊ ጽሑፉ ውጤታማነት የተዘጋጀውን መጠይቅ በታማኝነት በመሙላት እውነተኛና ጠቃሚ መረጃ ትሰጡን ዘንድ በአክብሮት እንጠይቃለን።
- በዚህ መጠይቅ ላይ የሚሰጥ ማንኛውም ምላሽ ሚስጥራዊነቱ የተጠበቀ እና ከጥናት ቡድኑ በስተቀር ማንም የማይመለከተው መሆኑን በአጽንኦት እንገልጻለን።
- ጊዜ ሰጥተው የምርጫ ጥያቄዎችን በማክበብ ተገቢውን ምላሽ በመስጠት እንዲተባበሩን እንጠይቃለን።

**ውድ የሆነ ሰዓትዎን ለእኛ ሰጥተው ይህን መጠይቅ ስለ ሞሉ እናመሰግናለን።**

**ስለሺ ሰጥቶ**

**ስልክ: +251 920 23 48 19**

**ክፍል አንድ:-ለሚከተሉት ጥያቄዎች በመምረጥ አክብቡ::**

- |                |  |   |
|----------------|--|---|
| 1. ያታ          | ሀ.ወንድ  | ለ. ሴት                                     |
| 2. እድሜ         | ሀ. 18-25 ዓመት<br>መ. 45-55 ዓመት                       | ለ.26-35 ዓመት ሐ.36-45 ዓመት<br>ሠ. ከ55 ዓመት በላይ |
| 3. የትምህርት ደረጃ: | ሀ.የመጀመሪያ ደረጃ(1-8)<br>ለ. የሁለተኛ ደረጃ (9-12)<br>ሐ.ዲፕሎማ | መ.የመጀመሪያ ዲግሪ<br>ሠ.የሁለተኛ ዲግሪ እና በላይ        |
| 4. የሥራ ሁኔታ     | ሀ.የመንግስት ድርጅት ተቀጣሪ<br>ሐ. የንግድ ድርጅት ባለቤት            | ለ. የግል ድርጅት ተቀጣሪ<br>መ. ተማሪ                |
| 5. የሥራ ኃላፊነት   | ሀ. በዋና ኃላፊነት<br>ለ. በምክትል ኃላፊነት                     | ሐ. በመደበኛ ሠራተኝነት<br>መ. ተማሪ                 |

**ክፍል ሁለት :-ጥያቄውን በጥንቃቄ ካነበቡ በኋላ ትክክለኛውን መልስ ይምረጡ**

1. የመንገድ ትራፊክ መጨመር ለማህበራዊ ፤ ለኢኮኖሚያዊ እና ለፖለቲካል እንቅስቃሴ ከፍተኛ ተጽእኖ አለው::

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

2. የመዘግየት ወጤቱ ሰራተኞች በስራ፤ በስብሰባ እና በትምህርት ላይ ከፍተኛ ተጽእኖ አለው::

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

3. የመንገድ ትራፊክ መጨመር የጉዞ ስዓትን እንደጨምረ እና በተገቢው በስራ ስዓት አለመድረስን ያስከትላል::

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

4. የመንገድ ትራፊክ መጨመር የነዳጅ መጨመርን፤ የአየር ብክለትን ያስከትላል::

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

5. የመንገድ ትራፊክ መጨመር የመኪናውን ክፍል ጉዳት እንደደርሰበት እና የጥገና ዋጋው እንደጨምረ ያደርጋል::

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

6. የመንገድ ትራፊክ ተጽዕኖ ለመገደቻች በጊዜ ላይከፍተኛ ተጽእኖ አለው።

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

7. የመንገድ ትራፊክ ተጽዕኖ በተማሪዎች ላይ የሳይኮሎጂ እና የትምህርት ድክመት ያስከትላል።

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

8. የትራፊክ መጨመር በማህበራዊ ጉዳዮች እና እንቅስቃሴዎች ላይ ከፍተኛ ተጽእኖ አለው።

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

9. የትራፊክ መጨመር በጤና እና በአካባቢ ብክለት ላይ ከፍተኛ ተጽእኖ አለው።

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

10. የትራፊክ መጨመር ለአደጋ፣ ለሞት እና የንብረት ብክለትን ያስከትላል።

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

11. የትራፊክ መጨመር የትራንስፖርት ዋጋ እንደጨምረ ያደርጋል።

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

12. የመንገድ ትራፊክ መጨመር የተሽከርካሪውን ክፍል ዋጋ እንደጨምረ ያደርጋል።

ሀ. በጣም እስማማለሁ ለ. እስማማለሁ ሐ. ግሉል መ. አልስማማም ሠ. በጣም አልስማማም

**ክፍል ሦስት:**

1. በራስዎ አስተያየት የመንገድ ትራፊክ መጨመር ጉዳዩን ይዘርዝሩ?
2. የመንገድ ትራፊክ መጨመር መንስኤውን ይዘርዝሩ?
3. የአካባቢ ብክለት ማልት ምን ማለት ነው?
4. የመንገድ ትራፊክ መጨመር ችግርን ይዘርዝሩ?