ANISO ABDULLAHI OSMAN

ESTIMATING TOTAL TRAFFIC CONGESTION COSTS: A CASE STUDY OF MOGADISHU CITY, SOMALIA

NEU 2022

NEAR EAST UNIVERSITY

INSTITUTE OF GRADUATE STUDIES

DEPARTMENT OF CIVIL ENGINEERING

ESTIMATING TOTAL TRAFFIC CONGESTION COSTS: A CASE STUDY OF MOGADISHU CITY,SOMALIA

M.Sc. THESIS

Aniso Abdullahi OSMAN

Nicosia

July, 2022

NEAR EAST UNIVERSITY
INSTITUTE OF GRADUATE STUDIES
DEPARTMENT OF CIVIL ENGINEERING

ESTIMATING TOTAL TRAFFIC CONGESTION COSTS: A CASE STUDY OF MOGADISHU CITY,SOMALIA

M.Sc. THESIS

Aniso Abdullahi OSMAN

Supervisor

Assoc. Prof. Dr. Shaban Ismael ALBRKA

Nicosia

July, 2022

Approval

We certify that we have read the thesis submitted by **Aniso Abdullahi OSMAN** titled "**ESTIMATING TOTAL TRAFFIC CONGESTION COSTS: A CASE STUDY OF MOGADISHU CITY, SOMALIA**" and that in our combined opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Educational Sciences.

Examining Committee	Name-Surname	Signature
Head of the Committee:	Assist. Prof. Dr. Mustafa Alas	.....
Committee Member:	Assist. Prof. Dr. Hussin Yahia	.....
Supervisor:	Assoc. Prof. Dr. Shaban Ismael Albrka	.....

Approved by the Head of the Department

Prof. Dr. Kabir Sadeghi
Head of Department

Approved by the Institute of Graduate Studies

...../...../20...

Prof. Dr. Kemal Hüsnü Can Başer
Head of the Institute

Declaration

Hereby, I certify that all information contained in this document has been acquired according to academic standards and ethical principles. As required by these rules and conduct, I also declare that all material and results that are not original to this work have been cited and referenced in accordance with these guidelines.

Aniso Abdullahi OSMAN

..20/.07../..2022

Acknowledgments

I would like to extend my sincere gratitude to my advisor ASSOC. PROF. DR. SHABAN ISMAEL ALBRKA for his kindness, motivation, and knowledgeable counseling throughout this thesis. It has been a privilege for me to work and learn under his helpful advice and without his support and advice, this research could not have been done. I want to express my appreciation to all of the professors and instructors at Near East University for spreading knowledge and offering sincere and valuable support during the course.

My sincere gratitude and appreciation to my parents for their encouragement and support in helping me finish my master degree both directly and indirectly. Finally, I want to thank my brothers, sisters, and friends for helping me develop emotionally and physically throughout my life

Aniso Abdullahi OSMAN

Abstract

ESTIMATING TOTAL TRAFFIC CONGESTION COSTS: A CASE STUDY OF MOGADISHU CITY, SOMALIA

Aniso Abdullahi OSMAN and Assoc. Prof. Dr. Shaban Ismael ALBRKA MA,

Department of Civil Engineering, Faculty of Civil and Environmental Engineering,

Near East University, Nicosia.

July, 2022, 47 Pages

Traffic jams are a common annoyance for regular commuters. However, it is not as simple as many would like it to be to understand the impact on cities and the economy. Traveling to work instead of working; delaying (or canceling altogether) meetings due to long travel times; forgoing interactions between individuals or personal activities because of long travel times; and having to spend more time completing tasks than would otherwise be required were all major consequences of congestion. And in addition to that, Emissions can rise if vehicles are idling or crawling for longer periods of time and experiencing more frequent acceleration and deceleration. The environmental impact will be greater as a result of this. Traffic congestion has emerged in Mogadishu as a result of the city's rapid economic and population growth, and the problem is only getting worse. Using SIDRA intersection software, this research measured the degree of traffic congestion in a selected area of Mogadishu. Two intersections were used to collect data on travel time, traffic volume, and travel speed. As a result, we were able to determine the rate of travel, the rate of delay, and the overall delay (in vehicles minutes, and minutes per minute). The total cost of congestion was also calculated using Sidra Intersection Software. There was an average of 826 veh – min and 616 veh – min in the morning and evening peak periods at those approaches, according to the study results. The total cost of congestion was above Shilling 154654.07per year for a specific approaching distance.

Keywords: Traffic congestion, delay, intersection, roundabout, Somalia

Table of Contents

Page

List of Figures

Page

List of Tables

Page

List of abbreviations

AVD: Average Delay

FUC: Fuel Consumption

HCM: Highway Capacity Manual

LOS: Level of Service

PCU: Passenger Car Unit

CO_2: Carbon dioxide

SIDRA: Signalized and Un-signalized Intersection Design, and Research Aid

NCHRP: National Cooperative Highway Research Program

LT: Left Turn

TH: Through

RT: Right Turn

AM: Ante Meridiem

PM: Post Meridiem

CHAPTER I

Introduction

Due to rising population, the fast expansion of motor vehicles and associated infrastructure, as well as the spread of ride-sharing services, traffic congestion has become a global concern (Altrincham, UK, 2019). Researchers have used a variety of terms to describe congestion. The most common description of jam in flow of traffic is that when the number of travelers surpasses of the roadways. Delays and additional travel time are caused by traffic congestion traffic jams occur when a large amount of vehicles block the regular flow of traffic. (Cambridge, MA, USA, 2005). When normal traffic flow is disrupted, the cost to the road user increases, which is another way to measure congestion (Victoria, BC, Canada, 2007). Congestion is caused by a wide range of factors in most urban areas around the world. These different causes of congestion allow us to distinguish between recurrent and non-recurrent forms. As a result of the high volume of traffic during rush hour, there is often reoccurring congestion (FHWA accessed on 10 December 2019).

In the last few years, traffic congestion has had a significant impact on the economy, society, and the environment. Congestion has a significant impact on the city's transportation system, especially in densely populated areas [Armah, F.A.; Yawson, D.O.; Pappoe, 2010) (Schrank, D.; Eisele, B.; Lomax, T.; Bak, J 2015). 1.31 billion gallons of additional fuel were purchased and 6.9 billion additional driving hours were logged in the United States (US) in 2014 due to traffic congestion (Pishue, B. U.S, 2017). Due to the ever-increasing number of cars on the road, this is a necessity.

Due to the lack of efficiency, congestion will cause a variety of issues. In a congested area, vehicle speeds will fluctuate at the same time, resulting in a lower average speed and a higher cost. Because of this, road users will incur higher vehicle operating costs and lose more time due to the increased cost of transportation. In other words, congestion will lead to an increase in transportation costs. As a result, proper quantification and measurement of congestion is critical for understanding the current road network's performance and for evaluating proposed congestion mitigation measures.

Problem Statement

Mogadishu is one of Somalia's largest cities, with substantial traffic congestion at numerous intersections and city streets. Among the various roads, the one from "Dabka to KM4" is a newly constructed residential and business district. There is a lot of traffic during peak and off-peak hours for drivers and passengers on the study, with the most prevalent vehicles being private automobiles, minibuses, medium buses, public buses, and various Lorries. The following are the primary consequences of traffic congestion: it causes people to be late for work; it causes people to be late for appointments:

- ✓ As a result of this, drivers and passengers may become angry, resulting in road rage;
- ✓ It makes us anxious even before we arrive;
- ✓ It is impossible to guarantee that deliveries will arrive on schedule or at a certain level;
- ✓ Lower production, and thus economic growth, in a country.

Aim and objectives of the Study

The Aim of the Study

The primary objective of this study is to calculate the total cost of traffic congestion in Mogadishu, in this case on the KM4 to Dabka Road, and to suggest viable solutions.

The Specific Objectives of the Study

- ✓ To analyze the traffic congestion on the selected area.
- ✓ To evaluate the level of service and also to estimate the total traffic congestion costs in the selected area using SIDRA intersection software.

Significance of the Study

Currently, Mogadishu's day-to-day activities are adversely affected by traffic congestion. Using the best indicators and measures, estimating the cost of traffic congestion will be necessary. As well as estimating the costs and consequences of congestion. When it comes to urban development and transportation policies, it will be critical for planners and policymakers to take into account future demographic shifts, and also consider countermeasures and make recommendations.

Limitation of the Study

Recurring and non-recurring traffic congestion are the two main types of traffic congestion. However, this study took into account the first type of congestion, which can be seen throughout the day in Mogadishu. The researcher only used a single day's worth of traffic counts for this study. Traffic congestion costs can be difficult to estimate because of time and budget constraints, as well as a variety of variables. Only three variables were used in the study because they were thought to be critical in determining the true cost of congestion. Because of the large number of people it is necessary to take into account the total cost of congestion. Light-duty vehicles such as minibuses, taxis, minibuses, and standard buses are commonly used.

CHAPTER II

Literature Review

The old adage, "Time is money," is as relevant today as it ever was. A company's profitability and output are likely to increase if it can produce high-quality products faster than its competitors. If all else is equal, a city with shorter commute times will have more productive workers than a city with longer commutes, The goal of economic policy is to increase productivity. Increased economic growth and the creation of new jobs are both correlated with higher productivity.

Researchers in Lagos, Nigeria, have examined the city's traffic issues (Bashir and Waziri 2008). 57% of drivers and commuters report spending 30 to 60 minutes stuck in traffic, according to a new study. Moreover, they discovered that Mondays were the most congested days of the week for travel. According to the findings of the study, the following factors are to blame for the city's traffic woes: Poor drainage, flooding, vehicle breakdown, narrow roads, religious events, potholes, and on-street parking are just some of the issues that plague some crossroads in the area. Congestion is well-known to the general public and those who use the roads on a regular basis as a serious obstruction to traffic flow. However, numerous documents revealed that little effort was made to conceptually examine congestion prior to the 1990s.

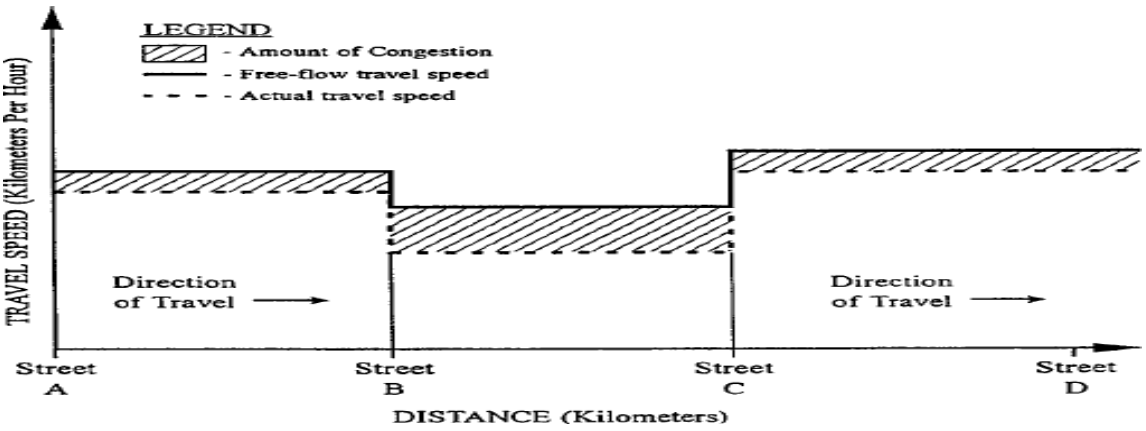
Traffic Congestion

While driving and trying to use the road network simultaneously, "congestion is the inconvenience that travelers impose on each other while using their vehicles and due to traffic density and speed (with due consideration of capacity)" states the Transportation Canada. SPEED, DENSITY, and FLOW are the three variables used to describe how fast a given stretch of road moves traffic. $Q = K * V$ is the equation that connects traffic density (vehicles per kilometer) and speed (km/hour). All else being equal, the more vehicles on a given road, the higher the traffic density, the slower the speed and the longer the journey. The engineering definition of congestion is based on this traffic flow Principle. Canada's transportation system (2006). Figure 1 below, from the NCHRP-398 report, illustrates a

precise definition of road traffic congestion.

Figure 1

Definition of Congestion



This graph demonstrates how congestion varies from location to location, even though it is slower than the free flow speed.

Types of Congestion

Recurring and non-recurring congestion are included in the definition. Driver behavior can be affected by a variety of factors, including the frequency and predictability of traffic jams. Congestion costs are likely to vary depending on the type. It may be more difficult to estimate non-recurring congestion costs due to the lack of adequate data. A number of experts believe motorists' expenses are higher than they should be because they failed to account for the possibility of traffic congestion when making their plans. Non-recurring congestion, such as in accident black spots, is becoming more common on some routes. The cost of delays and successful contingency routes can be "learned" in these situations. (Laird and colleagues, 2006).

Congestion Indicator

In traffic engineering, it's critical to know exactly how much a facility can hold under what operational conditions it can do so. Consider a situation where the road is an expressway with multiple lanes. Every part of it is unique in some way. Multilane highways are defined by HCM using three performance metrics:-

- ✓ the number of cars per kilometer of road per lane,
- ✓ speed as measured by the average speed of a passenger car, and
- ✓ Ratio of volume to carrying capacity.

Taking each of these measurements gives an idea of how well the highway is able to handle the current volume of traffic. Measurement of these two variables is more time consuming and labor intensive than the traffic volume counts that are currently used to estimate congestion.

Cause of Congestion

Congestion has many immediate causes, comprising an excess of traffic in relation to the design or capacity of a particular road, and also dynamic changes in the capacity of the roadway as a result of lane switching and car-following practices. Some of the many indirect effects include land-use patterns, employment trends; income levels; automobile ownership; infrastructure investment; and regional economic dynamics. Both macro-level (such as traffic flow "on the road") as well as micro-level (such as environmental conditions) factors can be implicated in the development of an event (e.g., demand for road use). The "micro" level (such as a road) and the "macro" level are both "triggered" in this context, and this causes congestion.

Impacts of Congestion

Traffic jams cause long lines, slower speeds, and more time on the road, all of which raise the cost of living in urban areas and negatively impact the quality of life for residents. Direct and indirect effects of traffic congestion on non-vehicular road users and non-vehicular road frontage properties are discussed at length at the European Ministers' Conference. These impacts need to be taken into account by policymakers, as well as take the time to understand such as the sort of urban centers people want to live in. The impact of traffic congestion on various modes of transportation is examined in this study. Recent years have seen an increase in interest in the costs associated with traffic congestion.

Recommended Congestion Measure

There are numerous ways to measure congestion that have been developed over time. However, new measures and indices have been developed as part of this research project. Some are easy to understand and apply, while others are more complicated. The primary process of congestion measurement should be based on travel time and delay. – A crowded roadway or system is made up of four components, according to Lomax et al. (1997): These include duration, intensity, and reliability. They differ between and within cities – smaller cities, for instance, smaller cities have shorter traffic jams.

- ✓ Duration: Congestion can have a detrimental effect on the transport network for this long.
- ✓ Extent: It is possible to estimate how many people or vehicles are harmed by traffic congestion and then map out the locations where that congestionoccurs.
- ✓ Intensity: This graphic illustrates the debilitating effects of heavy traffic on the ability to travel. Congestion levels on transportation networks are commonly referred to as "overcrowding" or "overcrowding."
- ✓ Reliability: A congestion estimation component is characterized as the variability in the other three components.

According to NCHRP report 398 "Quantifying Congestion," there are a variety of ways to quantify congestion. A road section's congestion can be better understood if multiple congestion measures are used, as most measures only address one or two aspects of the problem. Because of this, a wide variety of solutions to the various problems caused by traffic congestion have been proposed in various academic publications. There are a variety of measures that can be taken to reduce traffic congestion, as shown in the following table:

Table 1.

Different Types Congestion Measures

Travel Rate (minutes per mile)	$= \frac{Travel\ Time\ (minutes)}{Segment\ Length\ (miles)} = \frac{60}{Average\ Speed\ (mph)}$
Delay Rate (minutes per mile)	= Actual Travel Rate _ Acceptable Travel Rate (minutes per mile) (minutes per mile)
Total Segment Delay	= [Actual Travel Time _ Acceptable Travel Time] * Vehicle(minute) (minute) volume(vehicles)
Relative Delay Rate	$= \frac{Delay\ Rate}{Acceptable\ Travel\ Rate}$
Delay Ratio	$= \frac{Delay\ Rate}{Actual\ Travel\ Rate}$
Congested Travel	= $\sum$ Congested segment length * Traffic Volume (miles) (vehicles)

Measuring the Level of Service (LOS)

Congestion in the scheme must be defined or have identifiers of its presence. Cottrell (2001) LOS, according to these and other researchers, is a good predictor of traffic congestion in the transportation system. According to Lomax (1997), a road segment or crossroads can also be classified as crowded or not based on whether or not its users consider the congestion to be "acceptable" or "unacceptable".

Table 2.

Service Criteria for Different Intersection

	Signalized Intersection	Un-signalized Intersection
Level of Service	Average Control Delay (s/veh.)	
A	≤ 10	0 – 10
B	>10 – 20	>10 – 15
C	>20 – 35	>15 – 25
D	>35 – 55	> 25 – 35
E	>55 – 80	>35 – 50
F	>80	>50

CHAPTER III

Methodology

When conducting a study, the methodology used is critical in ensuring that the results are in line with the goal or the research question. To that end, the methodology and the rationale for the choice of methods in Chapters 1 and 2 of the thesis are discussed in this section of the thesis.

Research Approach

This study used a combination of qualitative and quantitative descriptive research designs, which allowed the researchers to accurately and adequately interpret their findings. As a consequence, the prevailing road traffic, road qualities, and traffic costs were all measured in this study. The amount of fuel consumed, the time it adds to the trip (delay), and the CO2 emissions that result from vehicles using more fuel than they should in normal and congested conditions are also discussed.

Throughout this thesis, the research methods used were designed so that the most important questions could be answered. A key question to ask is "does traffic congestion exist at this location?" to determine whether or not the intersections or road sections are congested. Congestion indicator parameters were used to raise the question, and the answer came first? LOS, as well as travel times and speeds, are included in the metric, were all used as congestion indicator parameters in this study. SIDRA's widely used SIDRA software was used to calculate the LOS criterion in accordance with HCM-2000.

Description of Study Area

Somalia's capital and most populous city, Mogadishu (also known as Xamar or Hamar) is located in the country's central highlands. For millennia, Mogadishu has served as an important port for traders from all over the Indian Ocean, and the city's current metro area population in 2022 will be 2,497,000, up 4.56 percent from 2021. There are numerous types of intersections in the study area, but two of them are deteriorating rapidly due to traffic congestion. This research topic was selected for the reasons stated above. The following are the intersections to be studied: - KM4 roundabout, Dabka Intersection.

Description of Km4 Intersection

The first point of congestion in the neighborhood is at this intersection. TALEEX is the first approach, ADAN ADE is the second, SOBE is the third, and ABDIQASIN is the fourth approach to this roundabout.

Description of Dabka Intersection

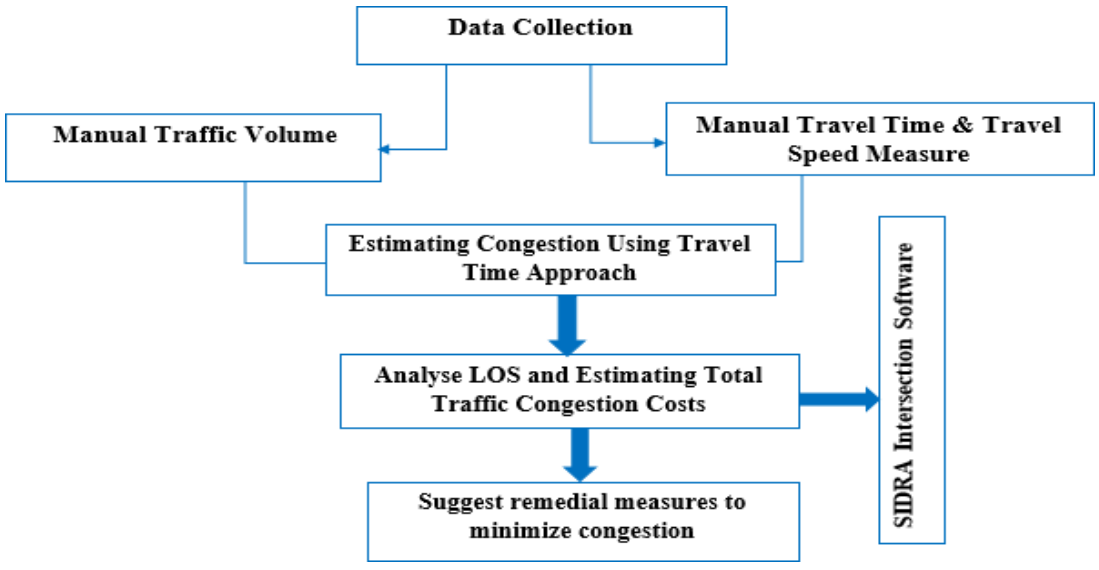
The second most congested intersection in the area is located here. At BAKARAHA, SAYIDKA, BUUNDADA, and KM4, is the four approaches of the intersection.

Method of Data Collection

Preliminary evaluations were conducted on-site at selected city traffic congestion points during a reconnaissance visit to the study area. After that, both sets of data must be properly analyzed in order to achieve the study's goals. As a final step, the recommended methods and procedures have been implemented in order to minimize mistakes. Figure 2 depicts the procedure used to gather the information shown in this report.

Figure 2

Outline Of the study



For peak and off-peak periods, traffic volumes were manually counted every 15 minutes to obtain traffic volume data. Traffic volume was counted at 15-minute intervals

for each peak and off-peak period, starting with the morning peak time of 7:30 AM–9:30 AM and ending with the evening off-peak hours of 11:00 AM–2:00 PM and 4:30 PM–7:30 PM.

Manual data on travel time will be gathered with a pen and paper, additionally, there is a discussion of the necessary equipment and personnel, as well as the associated costs. Pen and paper methods were improved by the introduction of audio tape recorders and portable computers. However, pen and paper discussions were the primary mode of communication.

A vehicle's travel speed is determined by determining the distance between two points of known location time intervals of the vehicle's starting time as well as its final destination. Finally, the relationship between distance and travel time data was used to calculate travel speeds, which if calculated manually, would have resulted in slower travel times (pen and paper method).Traffic Volume Data

For determining and understanding the flow pattern in the facility, traffic volume count data are critical. Peak flow rates and peak periods can be determined using these data. Furthermore, it is essential to evaluate a facility's level of service and quantify the level of congestion. Because of this, it was necessary to collect data on traffic volume at specific sections of road and intersections along the research corridor. Analysis of service levels has been done by calculating traffic volume at each intersection.

Table 3.

Amount of traffic in all directions

KM4 roundabout				
Date	Taleex Approach	AbdiqasinApproach	Sobe Approach	Adan ade Approach
13/12/2021	9308	4705	11078	7428

Table 3. (Continue)

Dabka Intersection				
Date	Bakaraha Approach	Sayidka Approach	Km4 Approach	Buundada Approach
20/12/2021	4133	5748	7701	6257

Field Measurement

The selected intersections' geometric features were measured in the field. Traffic lanes are the most important elements of the intersection layout, as are sidewalks on each approach, the number of lanes, the medians, and other streetside elements. Table (a) and (b) Summarize the collected data for the selected intersection and present the results in a graphical form.

Table 6.

Intersection Data from the Field

Approach	No	Width(m)	Width of median(m)	Type of line
Taleex	3	3.5	1	Normal
Abdiqasin	3	3.5	1	Normal
Sobe	3	3.5	3	Normal

Table 6. (Continue)

Adan ade	3	3.5	3	Normal
Lane for recirculation		3		
Width of circulating		10		
Diameter of island		60		

(a) Km4 roundabout

Approach Name	No. of Lane	Lane width(m)	Median Width(m)
Bakaaraha	3	3.5	1
Sayidka	3	3	1
KM4	2	3	1
Buundada	3	3.5	1

(b) Dabka intersection.

Table 7.

Dabka Intersection Signal Phasing

Phase Number	**Route**	**PCU Volume**	**Phase Green Time**
Φ1 bakaaraha	Left	315	35
	Tharough	765	
	Right	411	
Φ2 buundada	Left	567	35
	Through	650	
	Right	598	
Φ3 sayidka	Left	580	40
	Through	745	
	Right	400	
Φ4 km4	Left	204	40
	Through	918	
	Right	499	

CHAPTER IV

Results and Discussions

Using both quantitative and qualitative data, the authors of this study examined the traffic flow patterns at a handful of key intersections throughout the day in order to pinpoint when and where the most traffic occurs. The following sections provide an overview of the data that was gathered using the recommended procedure and the conclusions drawn from it.

Traffic Volume Analysis

Using a 15-minute traffic volume count, we were able to conduct a directional traffic volume study. Between the early morning and late afternoon and evening, a detailed daily traffic count was conducted. As a result, the two intersections' traffic volumes are analyzed from every angle.

Passenger Car Unit Analysis

When it comes to driving, there are many different types and styles of vehicles on the road. As a result, the driving habits of people in different types of vehicles can also differ greatly. Problems arise when it comes to road layout design as well as traffic signal planning. Mixed traffic flow necessitates an accurate measurement of vehicle volume and capacity. In order to do this, each type of vehicle must be referred to by a single standard vehicle unit. Other vehicle types were converted to Passenger Car Units (PCUs) as a result of the development of Passenger Car Equivalents (PCEs). PCU/hour, PCU/lane/hour, or PCU/kilometer are the most common ways to express it. (Rana and Mohit's 2016).

KM4 Roundabout Traffic volume

The KM4 intersection is a four-way roundabout intersection. All turning movements were taken into account during the traffic count, which lasted three hours during each of the day's peak and off-peak periods. Among the four approaches to the KM4 intersection, Sobe Approach sees the most traffic, Figure 3 demonstrates the variation of total traffic volume as depicted. It is the second busiest peak-hour route, after the Taleex Approach, behind this one. During rush hour, traffic on the Adan Ade and

Abdiqasin Approaches isn't too bad. A look at the intersection at km4 in Figure 4 shows the breakdown of the various vehicles.

Figure 3

Total Traffic Volumes Count Data for KM4 Intersection

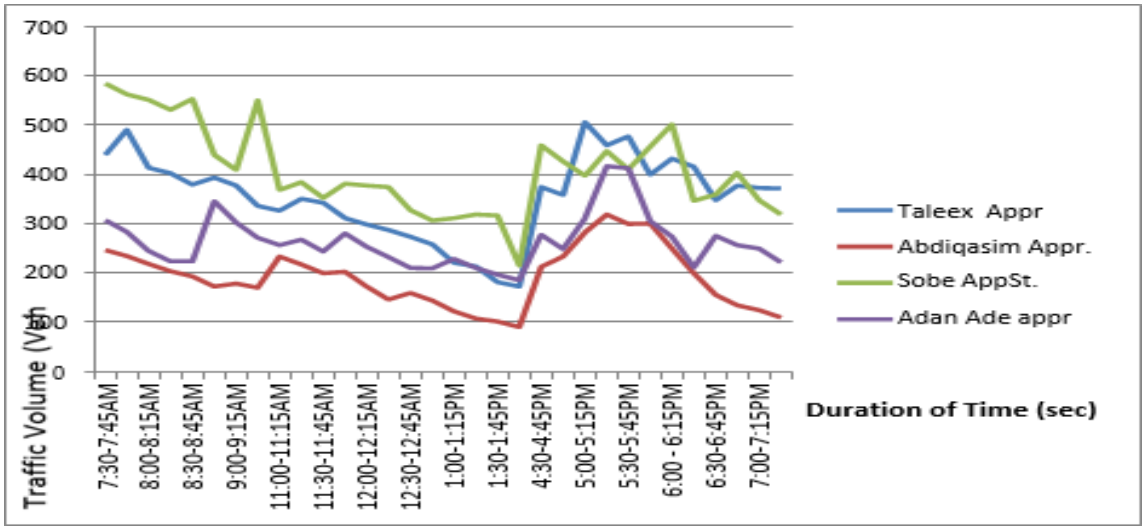
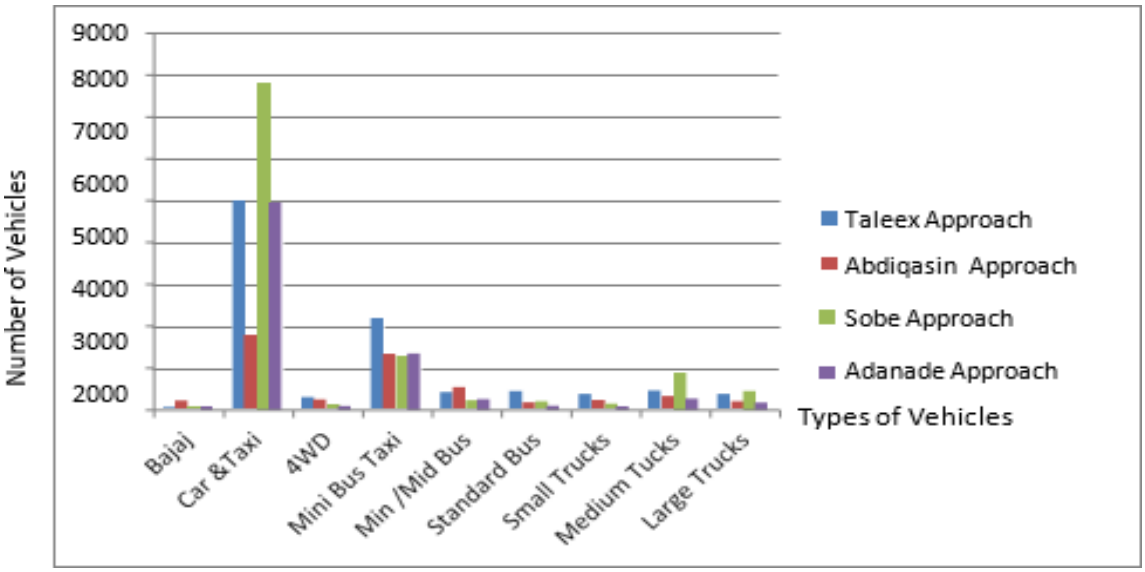


Figure 4

Total Vehicle Compositions at Km4 Intersection



The Km4 intersection has a variety of vehicle compositions, as depicted in Figure 4. Cars and taxis make up the majority of vehicles at this intersection, Medium-sized and large-sized trucks account for the majority of the remaining automobiles. The Sobe approach has the most car and taxi vehicle compositions of the four approaches. In terms of mini bus taxi, the Taleex strategy boasts the most diverse composition.

Traffic Volume at Dabka intersection

In the past, this intersection had a small roundabout with a narrow ring of traffic. Vehicles became congested as a result of this nature. Traffic lights have been installed in recent years. Traffic congestion is still a problem because of the intersection's geometric design. The current road capacity can't keep up with the current demand from road users. Figure 5 shows that during peak times, the km4 approach has the highest traffic volume, followed by the km4 approach. On the other hand, there is much less traffic on the rest of the approaches.

Figure 5

Total Traffic Volume Count Data for Dabka Intersection

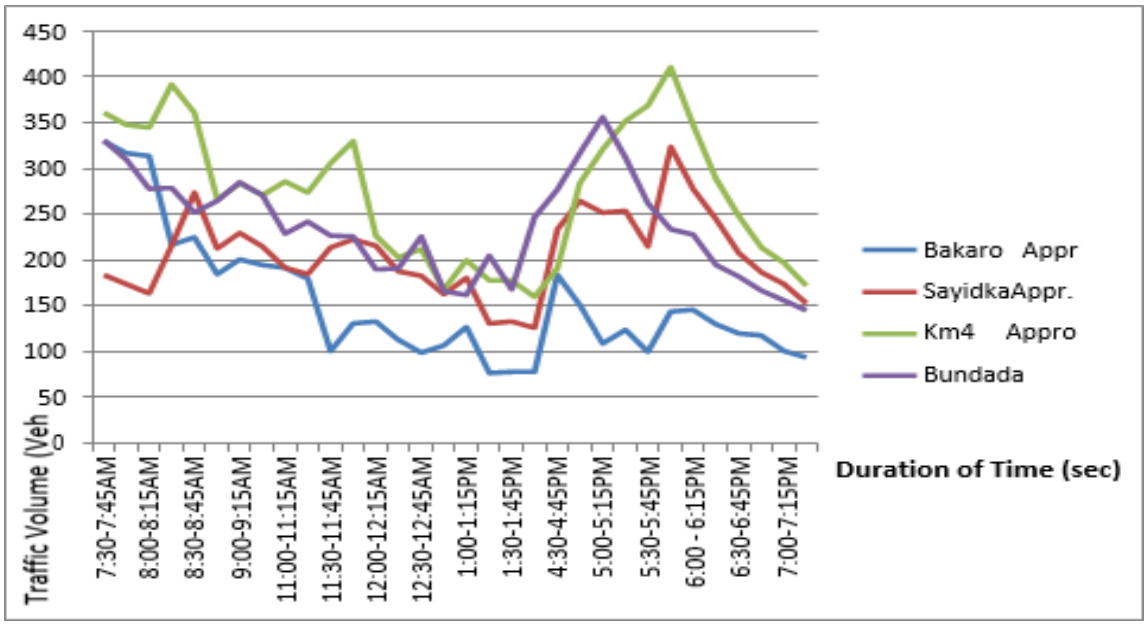


Figure 6

Total Vehicles Composition at Dabka Intersection

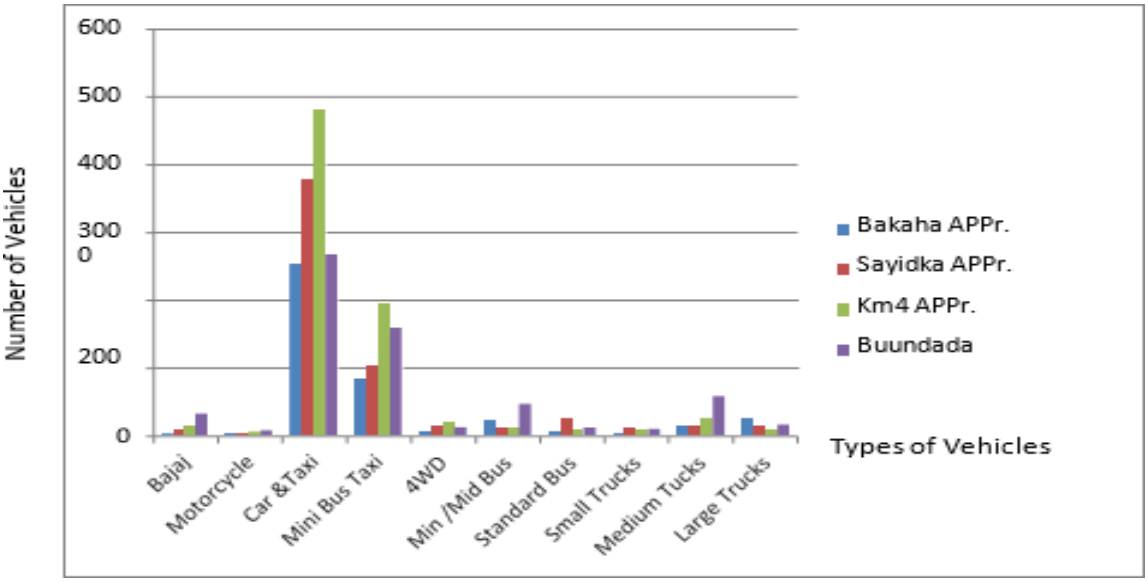


Figure 6 depicts the breakdown of traffic at the Dabka intersection in broad strokes. It is not surprising that cars and taxis have the most composition in each of the four approaches. In addition to minibus taxis, medium trucks, and mini/medium buses, this intersection also contains medium trucks. The Dabka approach is where you'll find the most cars and taxis.

Level of Service Analysis at Intersection

Using the SIDRA software package, an analysis was carried out to determine whether or not the intersections were congested. In order to conduct LOS analysis using Somalia's driving regulations, the software was configured to include options for right-hand driving and the HCM 2000 metric version. With minor adjustments and calibrations, the HCM 2000 metric version can be used around the world with the Highway Capacity Manual. For the purposes of this project, only the LOS will be determined in order to provide an indicative result.

LOS analysis used hourly geometric and directional volume traffic data summarized in Table 4.2 for preparation as an input data. Table 4.3 also shows the results of the LOS analysis, as shown in the following figure. For example, the critical gap and saturated flow were taken as recommended or default values for input data.

Table 8.

LOS Analysis Input Data

Intersections	Approach Leg	Number of Entry Lane	Number of Exit Lane	Lane Width(m)	Median Width (m)	Total Traffic Volume (veh)			Peak hour Factor (%)			Heavy vehicle Factor (%)		
						TH	RT	LT	TH	RT	LT	TH	RT	LT
Km4	Taleex	3	3	3.5	3	699	725	304	96.2	98	96	12.86	10.98	16.8
	Abdiqasin	3	3	3.0	3	250	200	150	80.1	80	80	1.2	2.1	1.5
	Sobe	3	3	3.5	3	865	281	845	97.8	95	94	13.31	13.28	13.6
	Adan ade	3	3	3.5	3	412	622	822	96.8	98	98	14	15.6	14
Dabka	Bakaraha	3	3	3.5	1	765	411	315	98.9	98	84	16.95	15.99	3.1
	Buundada	3	3	3.5	1	650	598	567	98.9	99	99	16.1	15.1	14.2
	Syidka	3	3	3.0	1	745	400	580	97.1	99	93	14.9	15.1	8.6
	Km4	3	2	3.0	1	918	499	204	97	93	88	5.29	15.1	5.85

Table 9.

LOS Analysis Output Data

		Delays(sec)			LOS		
Intersection	Approach Leg	LT	TH	RT	LT	TH	RT
Km4	Taleex	139.8	134.4	196.5	F	F	F
	Abdiqasin	459	463.3	458.3	F	F	F
	Sobe	238.3	236.5	235.9	F	F	F
	Adan ade	111.9	35.3	73.7	F	D	E

Table 9. (Continue)

Dabka	Bakaraha	351.4	343.7	352.7	F	F	F
	Sayidka	327.8	364.6	181.7	F	E	F
	Km4	360.4	352.1	370.4	F	F	F
	Buundada	362	353.3	373.3	F	F	F

Congestion Analysis

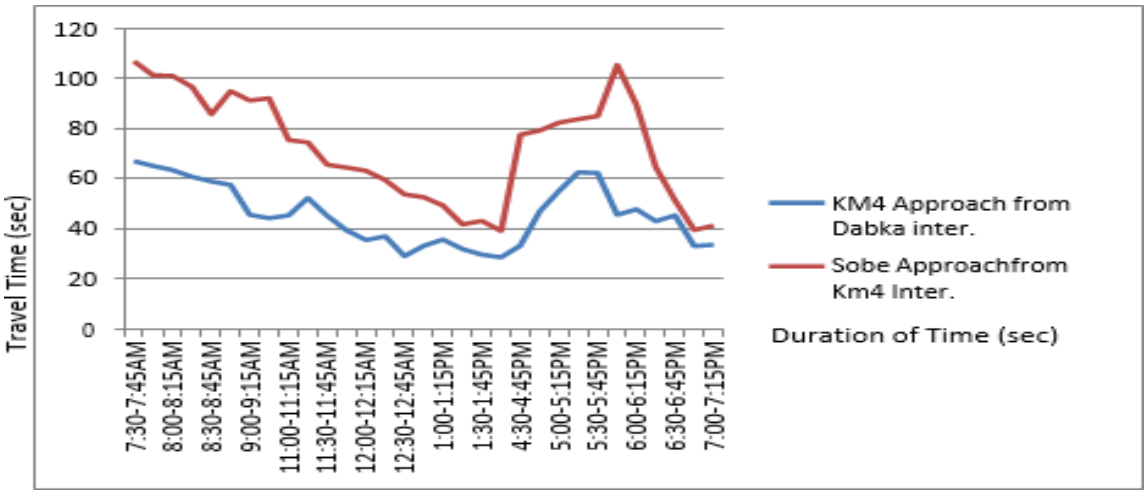
As a result of its many advantages, the researcher chose the Travel Time approach from the various congestion analysis approaches. Over the course of the study, metrics such as total segment delay and delay ratio were compared with other congestion indicators. As a result, each parameter is discussed in detail in the following sections.

Travel Time

As shown in Figure 7, the segment selection has an average travel time of 15 minutes at 15 minute intervals. Travel times were highest and lowest at midday off-peak times in the morning and evening, respectively. When comparing the various approaches, the Sobe route takes the longest time to travel during rush hour in the morning and evening. In addition, the Km4 route has the second-longest journey time.

Figure 7

Travel Time for Selected Approaches (Sec)

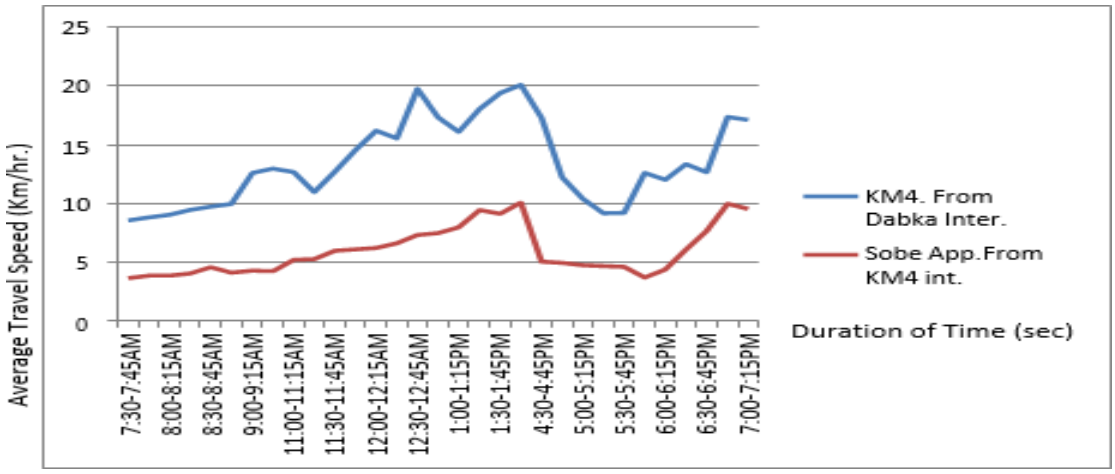


Average Speed and Travel Rate

The graph below displays the average speed at which vehicles travel in the study's congested road sections. Up until midday, the sections' travel speeds are less than 5 km/hr and less than 10 km/hr, respectively, in the morning. During the middle of the day, however, the maximum speed was reached. At noon, the highest speed recorded on the km4 approach is 20 kilometers per hour.

Figure 8

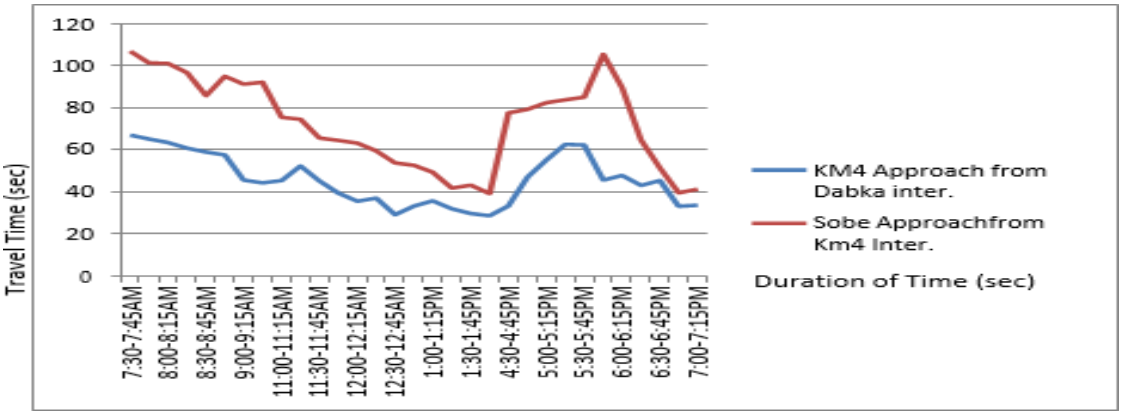
Average Travel Speed for Selected Approaches (km/hr.)



Rate," which is shown in Figure 9. The graph shows that peak travel times are in the morning and evening, while off-peak travel times are in the midday.

Figure 9

Travel Rate for Selected Approaches (min/km)



Delay Rate, Delay Ratio, Delay

Congestion measurement analysis heavily relies on delay as a key parameter in the morning period, when travel speeds at the sections are almost 5 km/hr and below 10 km/hr. Relative time delays are calculated using the posted approaching speed at intersections as a starting point. It is called "delay" when the time it takes to get from A to B is longer than what it would take in ideal or free flow conditions.

In traffic, the delay rate seems to be the time taken to get it from Destination to destination In order to figure out the difference in cost, the travel time rate is subtracted from the acceptable rate. Estimating the difference between system performance and expectations can be used to prioritize alternative improvement options. Freeways, arterial roadways and public transit routes may all be compared using the delay ratio to see how much congestion they are experiencing. Figures 10, 11, and 12 below present the results of Delay rate, Delay ratio, and Delay.

Figure 10

Delay for two Intersections (sec)

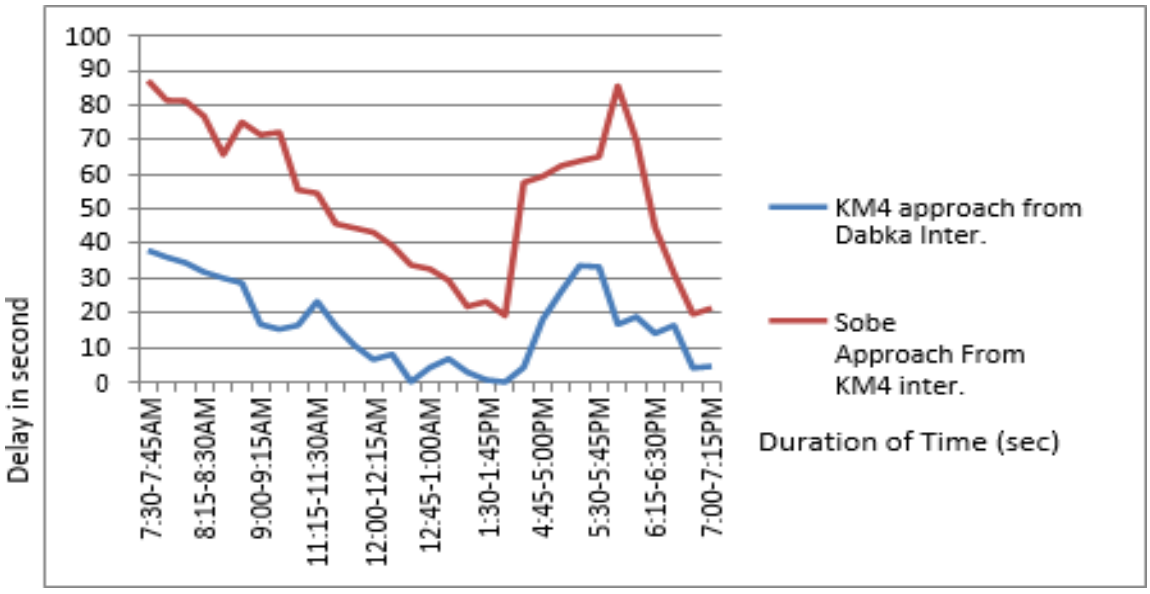


Figure 11

Delay Rate for two Intersections (min/Km)

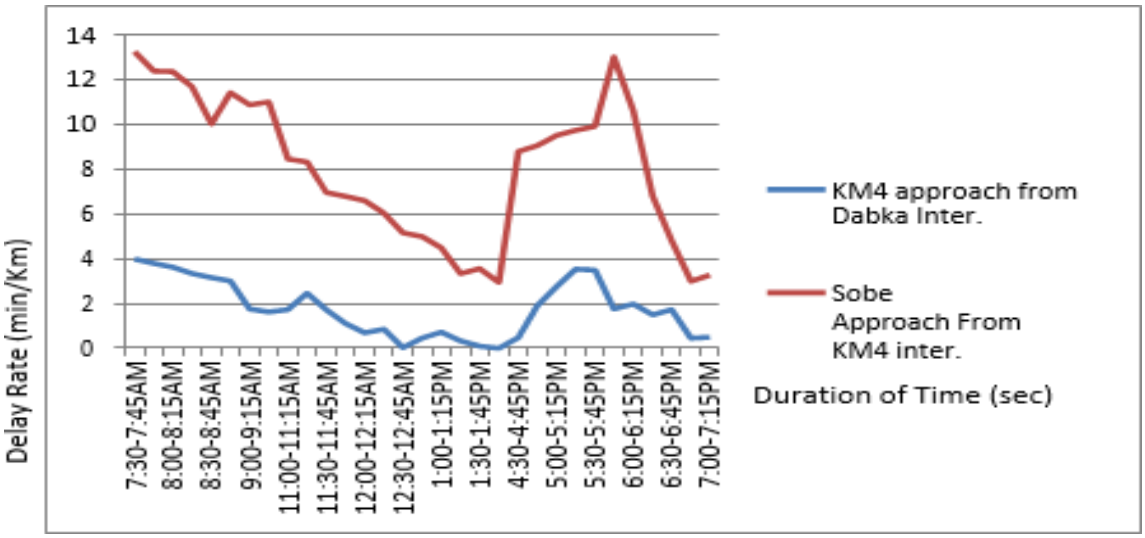
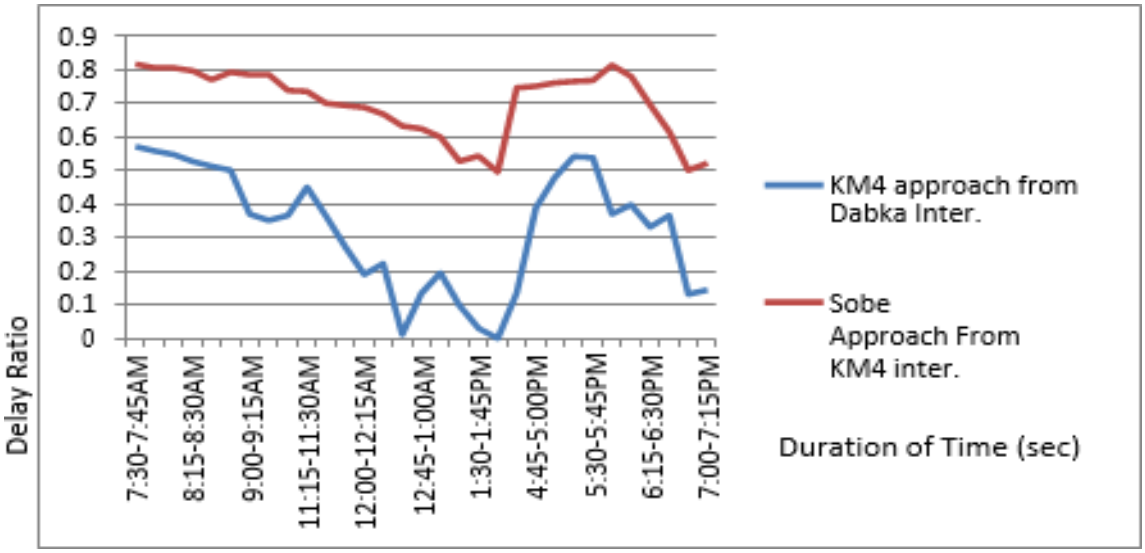


Figure 12

Delay Ratio for two Intersections



According to time-tracking data, the Sobe approach has the greatest delay from Km4 intersection in both the morning and evening rush hours, at 87.1 and 85.5 seconds,

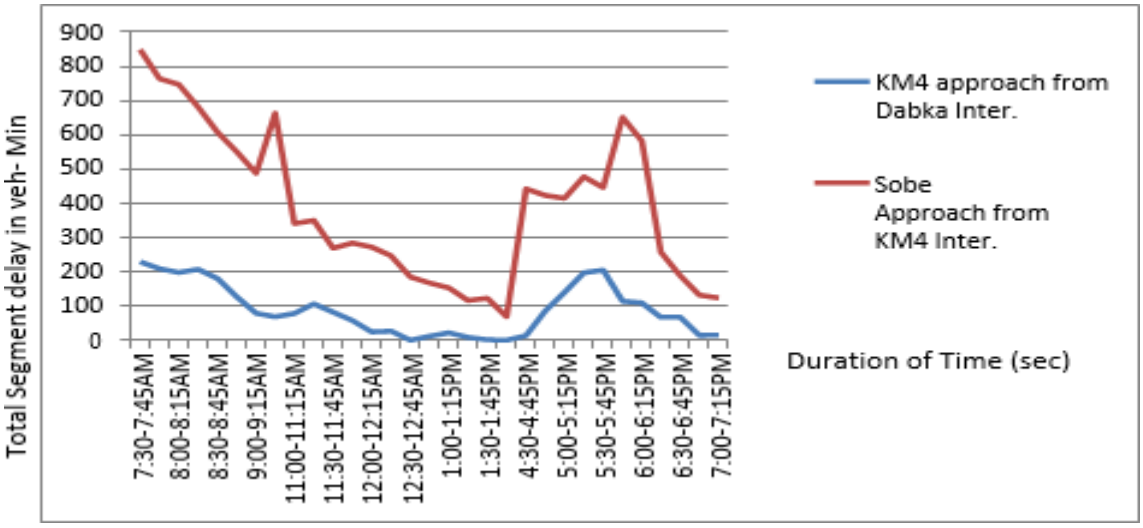
respectively. Figure 12 depicts the delay ratio as a proportion of delay to actual travel speed for each of the legs that were tested. As a result, the delay rate and delay ratio fluctuate throughout the day, depending on whether traffic is heavier in the morning or the evening. There were two intersections where the delay ratio ranged from 0.58 to 0.83.

Total Segment delay

Congestion intensity is measured by the total segment delay, in terms of vehicle-minutes and human-hours. It demonstrates the seriousness of the situation and the extent to which the backlog is affecting the lives of the general public. This figure displays the complete segment delay in Vehicle-Min for the leg length taken into consideration. The total delay, as shown in this graph, was calculated based on the segments' lengths using the approach selected. This means that instead of comparing the results for both legs, they should only look at the results for one leg.

Figure 13

Total Segment Delay for two Intersections (veh-min/meter)

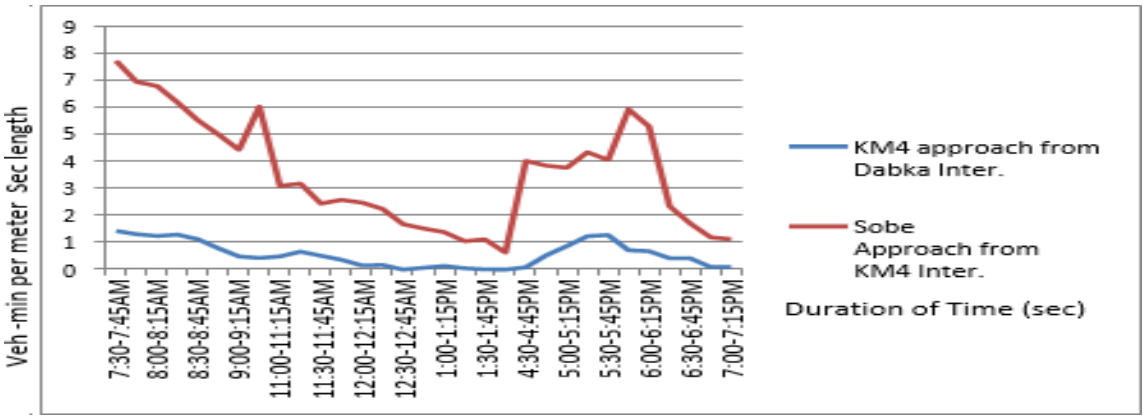


Both methods were compared and total delay was divided by the segment length and the delay was converted to a unit-length delaying. Because of this, as shown in Figure 14 below, Hana Maria approach experiences three times the congestion of the km4 approach during morning peak hours. 7:30 a.m. marks the start of the morning rush hour

at sobe, which lasts until well into the afternoon. After lunch, the traffic begins to build up again, peaking around 6:00 p.m. Sobe approach at km4 has more traffic than km4 approach, on average, according to this comparison.

Figure 14

Unit Length Delay



Causes of Congestion

Several factors contribute to Mogadishu traffic congestion, including a rapidly growing population, inadequate and poor road infrastructure. Using data from a volume count study, researchers have determined that heavier traffic and large trucks during morning and evening rush hours are to blame for KM4 intersection problems. This shows that congestion in developing countries is caused by a lack of proper planning, misuse of limited road networks, and bottlenecks.

Traffic Congestion Reduction Measures

These intersections have become congested due to a decrease in highway capacity as a result of increased traffic. In order to increase the highway's capacity, there are two options: either increase the highway's capacity or shift heavy vehicles to other roads. Heavy trucks travel a greater distance than other vehicles at KM4 intersections, as evidenced by the composition of those vehicles. As a result, rerouting those trucks to alternate routes will ease congestion. Second, the width of the intersection at Dabka is insufficient to accommodate the current volume of traffic. That's why this intersection should be upgraded to a well-built interchange like the one pictured here.

Input Data into SIDRA Intersection Software

In order to meet peak demand, the site level of service target was set to LOS D. Pump fuel price = 27Sh/L, Fuel Resource cost factor = 0.5 and the ratio of running costs to fuel costs is equal to 0.30. Vehicle Time Cost: Average income = 16 Sh/hr, Time value factor = 0.6.

Output Data from SIDRA Intersection Software

Table 10.

Total Cost Analysis Output Data for Both Intersections

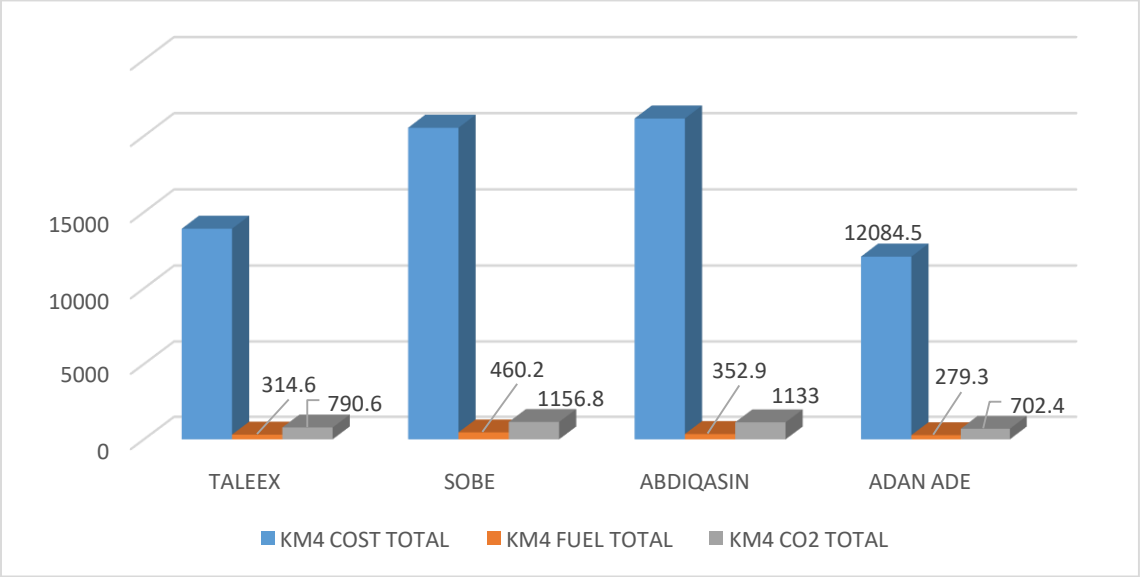
		APPROACHES				INTERSECTION
Intersection		Bakaaro	Buundada	Sayidka	Km4	
Dabka	Cost total	17873.5	22074.8	17147.6	18835.27	75931.17
	Fuel total	392.3	484.7	377.6	410	1664.6
	CO_2 total	986.1	1218.9	949	1028.7	4182.7
	Total					**81778.47**
Km4		Taleex	Sobe	Abdiqasin	Adan ade	Intersection
	Cost total	13913.1	20540.1	21147.1	12084.5	67685.8
	Fuel total	314.6	460.2	352.9	279.3	1407
	CO_2 total	790.6	1156.8	1133	702.4	3782.8
	Total					**72875.6**
	Over all total					**154654.07**

Cost Analysis for KM4 Intersections

In below figure 15 presents the results of Cost analysis with three different parameters which are: Cost total (Total vehicle operating cost and time cost), fuel cost total and CO2 emission cost respectively. After the analysis it was found that the Cost total are higher than the fuel cost and CO2 emission for all approaches.

Figure 15

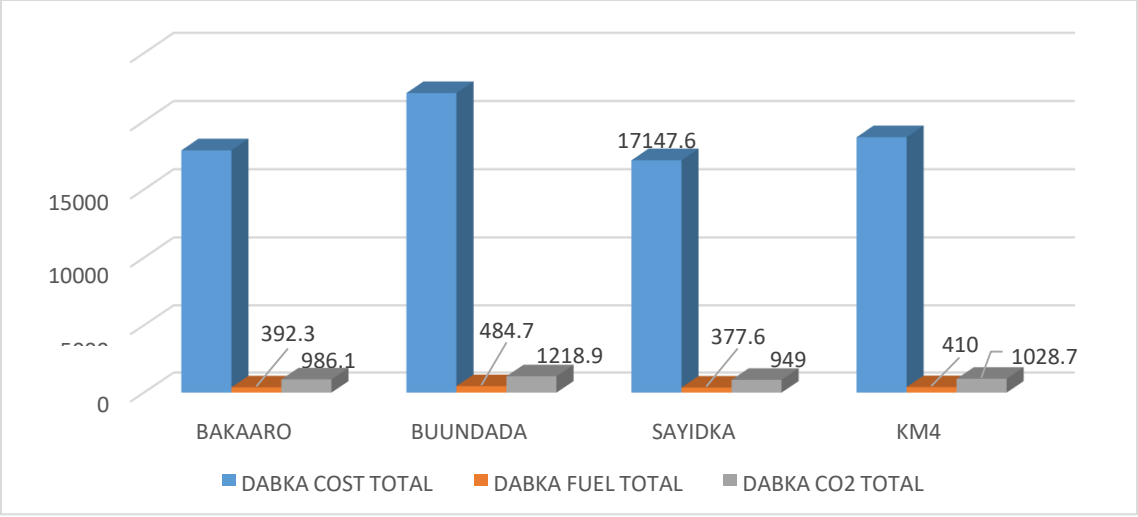
Cost analysis at KM4 Roundabout



Cost Analysis for Dabka Intersection

In below figure 16 presents the results of Cost analysis with three different parameters which are: Cost total (Total vehicle operating cost and time cost), fuel cost total and CO2 emission cost respectively. After the analysis it was found that the Cost total are higher than the fuel cost and CO2 emission for all approaches.

Figure 1
Cost Analysis at Dabka Intersection



CHAPTER V

Conclusion and Recommendations

Conclusion

In light of this study's findings, the following conclusions can be drawn.

- ✓ Two intersections have a congested nature in the morning and evening, according to total traffic volume distribution. In addition, the off-peak time is during the middle of the day, which is relatively free of traffic.
- ✓ For example, an intersection in KM4 with a LOS F almost for all approaches is exceeding its capacity, according to LOS data.
- ✓ Delays in the morning and evening peak periods can be found at the two intersections selected for this approach. There was a delay ratio of 0.58 to
- ✓ 0.83 at two intersections of two different Sobe and Km4 Approach approaches.
- ✓ In terms of veh-min., the selected intersections' average traffic congestion intensity was measured. According to the results, the morning and evening peak periods saw delays of 826 and 616 veh – min, respectively, on average.
- ✓ In the off-peak period and peak period the average annual cost of congestion for a specific approaching distance is Shilling 154,654.07.
- ✓ According to our findings, the primary reason for traffic congestion in those particular areas is the occurrence of vehicles operating at or near their maximum capacity. According to LOS analysis, the majority of intersection approaches are serving above their capacity.
- ✓ Total travel time are high comparing to the fuel consumption, and CO2

emissions all approaches, as can be seen from the Total cost of congestion analysis for both intersections.

Recommendations

Here's a suggestion for relevant policymakers to consider:

- ✓ Traffic volume was only counted for one day in this study because of time and budget constraints. For this reason, it is recommended that you keep track for at least a week. Automated data collection is preferable when collecting travel speed and travel time, as this reduces the risk of human error in the data.

- ✓ Costs of travel time, fuel consumption, and CO2 emissions were used to calculate the total congestion costs.

- ✓ According to the findings of the study, the intersections are being overtaxed. Consequently, the city administration should take into account this issue and devise capacity-enhancing strategies. It will also be less congested if those large trucks are moved to another route.

REFERENCES

Aftabuzzaman, M. (2007, September). Measuring traffic congestion-a critical review. In 30th Australasian transport research forum (pp. 1-16). London, UK: ETM GROUP.

Afrin, T., & Yodo, N. (2020). A survey of road traffic congestion measures towards a sustainable and resilient transportation system. Sustainability, 12(11), 4660.

Armah, F. A., Yawson, D. O., & Pappoe, A. A. (2010). A systems dynamics approach to explore traffic congestion and air pollution link in the city of Accra, Ghana. Sustainability, 2(1), 252-265.

Ahsani, V., Amin-Naseri, M., Knickerbocker, S., & Sharma, A. (2019). Quantitative analysis of probe data characteristics: Coverage, speed bias and congestion detection precision. Journal of Intelligent Transportation Systems, 23(2), 103-119.

Aworemi, J. R., Abdul-Azeez, I. A., Oyedokun, A. J., & Adewoye, J. O. (2009). A study of the causes, effects and ameliorative measures of road traffic congestion in Lagos Metropolis. European Journal of Social Sciences, 11(1), 119-128.

Berhan, E., Beshah, B., & Kitaw, D. (2013). Performance analysis on public bus transport of the city of addis ababa. International Journal of Computer Information Systems and Industrial Management Applications, 5(2150-7988), 722-728.

Bull, A., & Thomson, I. (2002). Urban traffic congestion: its economic and social causes and consequences. Cepal review.

BUREAU, O. I. T., & ECONOMICS, R. (2007). Estimating urban traffic and congestion cost trends for Australian cities. Department of Transport and Regional Services Canberra.

Cambridge Systematics. (2008). Cost-effective performance measures for travel time delay, variation, and reliability (Vol. 618). Transportation Research Board.

Christopher Zegras and Todd Littman, (1997). An analysis of the full costs and impacts of Transportation in Santiago de Chile.

Dr. Susan Grant-Muller & Mr James laird, (2006). Cost of congestion, literature based review of methodology and analytical approaches.www.schotland.gov.uk/socialresearch.

Dr.Eng. Demiss Alemu Amibe, (2004). Pilot global fuel economy initiative study in Ethiopia.

Demelash, Abate, March (2007). Analysing public transport performance using efficiency measures and spatial analysis; the case of Addis Ababa Ethiopia.

Eshetie Berhan, (2013). Performance analysis and route design of Addis Ababa Public Bus transport for partial fulfilment of PhD degree in Mechanical Engineering.

Falcocchio, J. C., & Levinson, H. S. (2015). Road traffic congestion: a concise guide (Vol. 7). Cham: Springer.

Fonseca, D. J., Moynihan, G. P., & Fernandes, H. (2011). The role of non-recurring congestion in massive hurricane evacuation events. In Recent Hurricane Research— Climate, Dynamics, and Societal Impacts (pp. 441-458). London, UK: InTech.

Ha. C, Andrew. B. And Michael, W. (2013). Updated Emission Factors of Air Pollutants from Vehicle Operations in GREET Using MOVES. Systems Assessment Section Energy Systems Division: Argonne National Laboratory.).

Haregewoin, Y. (2010). Impact of Vehicle Traffic Congestion in Addis Ababa (A Case study of Kolfe sub-city: Total -Ayer Tena Road). Addis Ababa: MSC Thesis, Ethiopian Civil Service College.

Institute of environment management and analysis corporate member. (2012). Carbon footprint calculator Ltd. Leicester, midlands UK. Available at http://www.carbonfootprint.co)m/aboutus.html.

Ian Douglas Greenwood, (2003), A New Approach To Estimate Congestion Impacts For Highway Evaluation -Effects On Fuel Consumption And Vehicle Emissions.

Ian Willis and David Lupton, (2013). The costs of congestion reappraised New Zealand transport agency.

Institute of Environmental Management and Analysis Corporate Member (2012).

Carbon footprint calculator Ltd. Leicester, Midlands UK. Available at http://www.carbonfootprint.com/aboutus.html.

Litman, T. (2007). Developing indicators for comprehensive and sustainable transport planning. Transportation Research Record, 2017(1), 10-15.

Lomax, T. J. (1997). Quantifying congestion (Vol. 398). Transportation Research Board.

Lomax, T., Wang, B., Schrank, D., Eisele, W., Turner, S., Ellis, D., & Geng, L. (2010). Improving mobility information with better data and estimation procedures (No. UTCM 09-17-09). Texas Transportation Institute.

M. Turner et.al (March 1998) Travel time Data collection handbook.

Madhu Errampalli et al (2014), International Journal for Traffic and Transport Engineering, 2015, 5(4): 458 – 472.

Narelle Haworth and Mark Symons. (2001).The relationship between fuel economy and safety outcomes, Report no.188/ monash University, accident research center.

Pishue, B. (2017). US Traffic Hot Spots: Measuring the Impact of Congestion in the United States.

Rakha, H.and Ding, Y. (2003). Impact of stops on vehicle fuel consumption and emissions. Journal of transportation engineering, Vol. 129, ASCE.

Systematics, C. (2005). Traffic congestion and reliability: Trends and advanced strategies for congestion mitigation (No. FHWA-HOP-05-064). United States. Federal Highway Administration.

Sekhar, C. R., Raj, P., Parida, P., & Gangopadhyay, S. (2013). Estimation of delay and fuel loss during idling of vehicles at signalised intersection in Ahmedabad. Procedia- Social and Behavioral Sciences, 104, 1178-1187.

Small, K. A., & Verhoef, E. T. (2007). The economics of urban transportation.

Routledge.

Syed Fazal Abbas Baqueria, Wim Ectorsa, Mir Shabbar Ali (2016), Estimation of Value of Time for a Congested Network – A case study of the National Highway, Karachi.

Tonne, C., Beevers, S., Armstrong, B., Kelly, F., & Wilkinson, P. (2008). Air pollution and mortality benefits of the London Congestion Charge: spatial and socioeconomic inequalities. Occupational and Environmental Medicine, 65(9), 620-627.

Tom van vuren & Neil hurts, (2008), Estimating & mapping the cost of congestion in metropolitan area, Journal of map, 4:1,485 498,DoI:10,4113/jom.2008.1024.

Transportation Research Board, (2002). The Congestion mitigation and air quality improvement program, Assessing 10 years of experience. Transportation Research Board, National Research Council, Washington, D.C, pp. 60e64.

The Indian road congress, IRC (106/1990) Guide line for capacity of urban road in plain area.

Umama A. (August, 2010). Passenger Car Equivalent Factors for Level Freeway Segments Operating under Moderate and Congested Condition. Published MSc thesis: Marquette University.

Victoria Transport Policy Institute (2013). Transportation Cost and Benefit Analysis II – congestion cost [online] available (www.vtpi.org)

Wang, J., Chi, L., Hu, X., & Zhou, H. (2014). Urban traffic congestion pricing model with the consideration of carbon emissions cost. Sustainability, 6(2), 676-691.

White, J. W., Dubey, A. D., & Sun, F. S. (2018). DxNAT—Deep neural networks for explaining non-recurring traffic congestion.

Weisbrod, G., Vary, D., & Treyz, G. (2001). NCHRP Report 463: Economic Implications of Congestion. Transportation Research Board. National Research Council, 72.

Washbrook, K., Haider, W., & Jaccard, M. (2006). Estimating commuter mode choice: A discrete choice analysis of the impact of road pricing and parking charges. Transportation, 33(6), 621-639.

World health organization. (2005). Health effects of transport related air pollution. WHO regional office for Europe, Copenhagen.

Appendix A

Table 1: LOS Analysis Input Data into SIDRA Intersection Software

Intersections	Approach Leg	Number of Entry Lane	Number of Exit Lane	Lane Width(m)	Median Width (m)	Total Traffic Volume (veh)			Peak hour Factor (%)			Heavy vehicle Factor (%)		
						TH	RT	LT	TH	RT	LT	TH	RT	LT
Km4	Taleex	3	3	3.5	3	699	725	304	96.2	98	96	12.86	10.98	16.8
	Abdiqasin	3	3	3.0	3	250	200	150	80.1	80	80	1.2	2.1	1.5
	Sobe	3	3	3.5	3	865	281	845	97.8	95	94	13.31	13.28	13.6
	Adan ade	3	3	3.5	3	412	622	822	96.8	98	98	14	15.6	14
Dabka	Bakaraha	3	3	3.5	1	765	411	315	98.9	98	84	16.95	15.99	3.1
	Buundada	3	3	3.5	1	650	598	567	98.9	99	99	16.1	15.1	14.2
	Syidka	3	3	3.0	1	745	400	580	97.1	99	93	14.9	15.1	8.6
	Km4	3	2	3.0	1	918	499	204	97	93	88	5.29	15.1	5.85

Appendix B

Ethical Confirmation

NEAREASTUNIVERSITY YAKINDOĞUÜNİVERSİTESİ

ETHICSLETTER

TOGRADUATESCHOOLOFAPPLIEDSCIENCES

REFERENCE:*ANISO ABDULLAHI OSMAN *(20206235)

I would like to inform you that the above candidate is one of our postgraduate students in the Civil Engineering department she is taking a thesis under my supervision and the thesis entailed: **ESTIMATING TOTAL TRAFFIC CONGESTION COSTS FOR SELECTED ROADS OF MOGADISHUCITY: A CASE STUDY OF KM4 TO DABKA ROAD,SOMALIA**. The data used in her study was our data collcted from the filed in Mogadishu City.

Please do not hesitate to contact me if you have any further queries orquestions.

Thank you very much indeed.

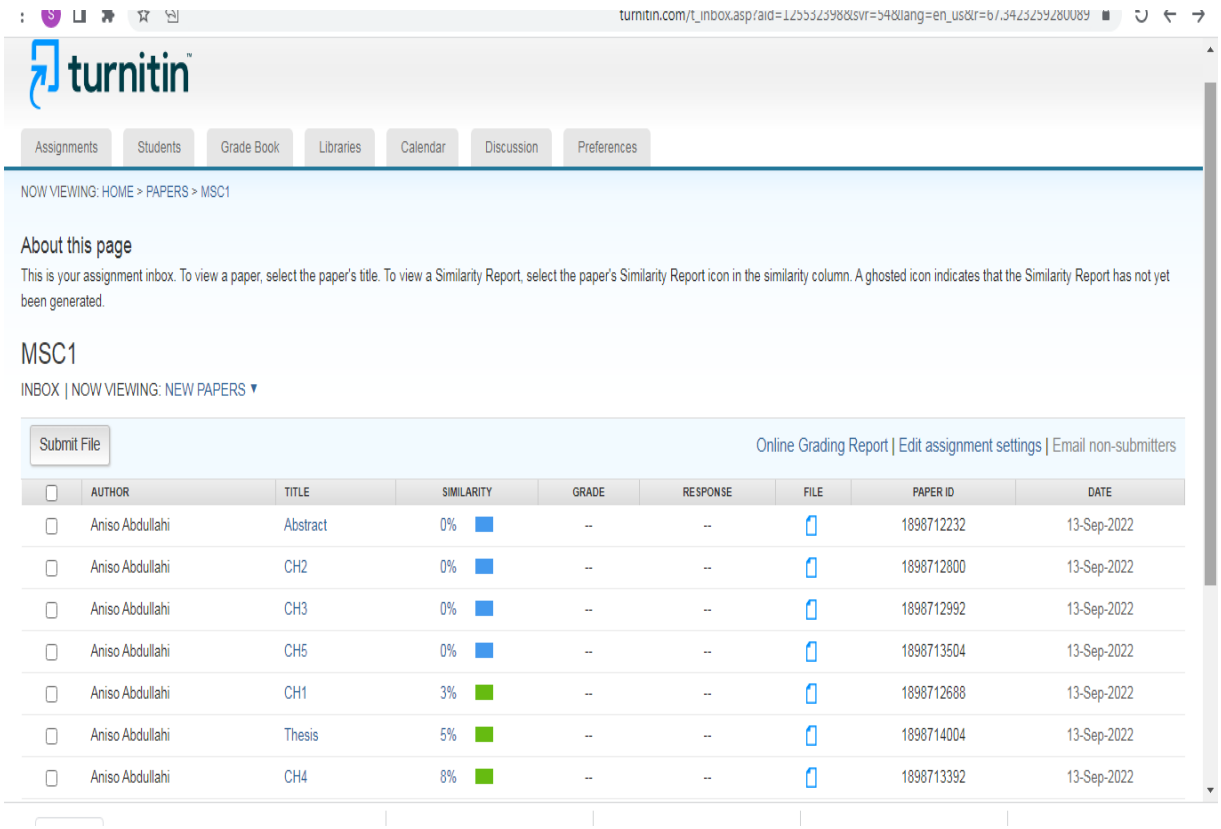
BestRegards,

Assoc. Prof. Dr.ShabanIsmaelAlbrkaAli

Student'sSupervisor& HeadofTransportationUnit
CivilEngineeringDepartment,
Faculty of Civil and Environmental
Engineering,NearEast Boulevard, ZIP: 99138
Nicosia / TRNC, North
Cyprus,Mersin10 – Turkey.
Email:shabanismael.albrka@neu.edu.tr

Appendix C

Turnitin Similarity Report



Assoc. Prof. Dr. Shaban Ismeal Albrka