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Integrating Socio-Economic and Traffic Factors: A New Perspective on Road Congestion Analysis

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ABSTRACT

The primary aim of this study is to evaluate road traffic congestion by considering not only the commonly utilized traffic-related parameters (micro level) but also the socio-economic factors influencing commuters (macro level). Analyzing these socio-economic parameters uncovers congestion causes that traffic parameters alone cannot reveal, such as the specific types of trips contributing to congestion during certain times.

This research focuses on traffic flow in Logiya town. A questionnaire was developed to collect data through interviews and document reviews. Furthermore, three key locations were selected for analyzing traffic parameters. The level of service (LOS) was assessed, and a travel time approach was employed to examine traffic congestion.

The findings indicate that a high volume of vehicles on the same road during peak hours is the primary cause of traffic congestion in the study area. Socio-economic data revealed that commuting trips are responsible for the most significant traffic congestion each morning and evening. Consequently, an immediate solution is to reroute heavy vehicles, such as trucks, via a bypass road during the day and restrict their entry into the town.

KEY WORDS: Traffic Congestion, Socio-Economic Factors, Trip Parameters

INTRODUCTION

In today's world, urban areas face challenges such as accidents, air and noise pollution, and traffic congestion. These issues are expected to worsen, particularly traffic congestion. Logiya town, located in the Afar region, is one of the rapidly growing towns, and as its population increases, so does the volume of traffic. Consequently, Logiya is currently experiencing significant traffic congestion, which negatively impacts residents in various ways. These impacts include delays that detract from daily activities, increased air and noise pollution, excessive fuel consumption by vehicles, and heightened operating costs, such as higher expenses for spare parts.

For business owners, this congestion leads to additional costs due to supply chain disruptions, increased inventory expenses to mitigate congestion effects, and lost time for workers. Employees may also suffer from fatigue, stress, and boredom, which can hinder their productivity.

Globally, many cities, especially in developing countries, continue to grapple with traffic congestion, resulting in substantial delays, wasted fuel, and financial losses. Small critical zones often emerge as hotspots for congestion, frequently stemming from poorly designed road networks and unauthorized roadway usage. Ineffective traffic management around these hotspots can exacerbate delays in traffic flow (Ahmed, Iyer, Ramesh, White, & Subramanian, 2023).

LITERATURE REVIEW

Traffic congestion refers to the condition of having excessive vehicles or slow-moving traffic on the roads, disrupting the flow of cars and hindering the movement of people and goods. This issue is particularly prevalent in urban areas, especially during rush hours when commuters are traveling to and from work. The negative impacts of traffic congestion can be significant, leading to longer travel times, increased air pollution, and financial losses due to wasted fuel and decreased productivity (Choi, Coughlin, & D'Ambrosio, 2013).

Researchers have defined congestion in various ways. The most common definition within the context of traffic flow is when the demand for travel exceeds the available road space (Aftabuzzaman, 2007). From the standpoint of delays and additional travel time, congestion occurs when a high volume

of vehicles disrupts the normal flow of traffic, resulting in delays. Another perspective characterizes congestion as the increased costs incurred by road users due to the disruption of regular traffic flow (Litman, 2013).

Traffic congestion is a widespread issue in metropolitan areas for several reasons. Notably, high population density contributes significantly to this phenomenon. Additionally, the growing prevalence of ride-sharing and delivery services, along with the infrastructure that supports them, further exacerbates congestion (Reed & Kidd, 2019).

Figure 1 congestion at the entrance of the town and piyassa station at Logiya town. (Source: Authors)

This research is limited to finding out factors affecting road congestion under mixed traffic conditions and possible solutions for the Logiya Town. The socio- and traffic parameters were only taken into consideration and other factors such as road geometry, illegal parking, and accidents were considered for this research.

Table 1. LOS analysis and Volume/capacity ratio

LOS	Description	Volume/ Capacity
A	Free- flow condition with unimpeded maneuverability, stooped at, stooped delay at signalized intersection is negligeable	0.00-0.60
B	Reasonably unimpeded operations with restricted maneuverability, stopped delays are not bothersome.	0.61-0.70
C	Stable operations with somewhat more restrictions in making midblock lane changes than LOS B. Motorists will experience appreciable tension while driving.	0.71-0.80
D	Approaching unstable operations where small increases in volume produce substantial increases in delays and low average speeds.	0.81-0.90
E	Operations with significant intersection approach delays and low average speeds.	0.91-1.10
F	Extremely low speeds caused by intersection congestion, high delay and adverse signal progression.	Greater than 1.0

Based on level of service Joshua and Iyiola (2009) measured average capacity/volume ratio and congestion as depicted in table 2.2 below.

Table 2 Average Capacity /volume ratio and congestion relationship

No.	Average traffic volume/capacity ratio	Technical interpretations
1	Less than 0.6	No congestion
2	0.6 to 0.8	Slight congestion
3	0.8 to 1.0	Congestion
4	1.0 to 1.2	Severe congestion

5	Greater than 1.2	Extreme congestion

STUDY AREA IDENTIFICATION

The study corridor connects the north-east and central regions of the country, where the majority of imports and exports take place, and is a very crowded route, but it is very important. The highway, which has a total length of around 8.4km within the town, connects Samara-Logiya with the trade hub of the north-eastern corridor that travels from Djibouti. The main, asphalted road between Addis Abeba and Djibouti provides access to the study region. Numerous junctions along the route in this segment lack traffic signals. A few of the road sections along the route are as follows:

Traffic Volume Analysis at Spot I

This road section carries traffic from the residential areas of the north direction of the city. Figure 2 shows that the traffic volume at old minibus station is peak volume during the mid-day 11:00 AM to 12:00 PM.

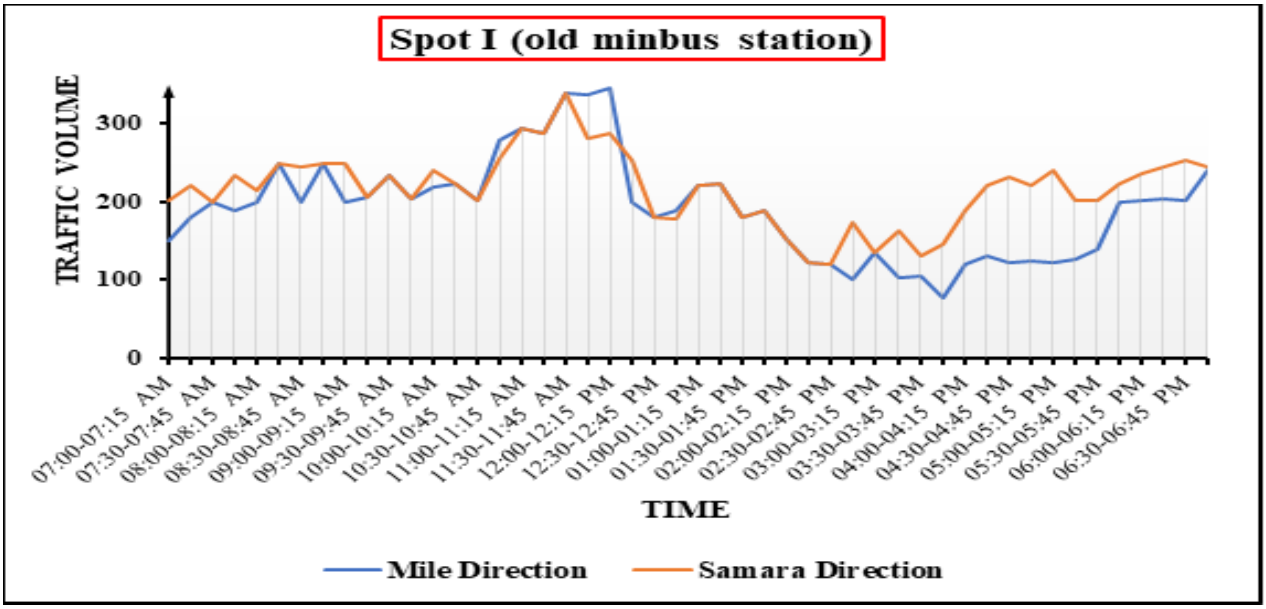

Figure 2. Traffic hourly volume at Spot I (Old Min Bus Station)

Traffic Volume Analysis at Spot II

This spot area is located at Piyasa station**,** and it has high congested area in and outlet traffic on both approaches and it has the highest traffic volume towards both approach in the mid-day peak period and it has the highest traffic volume in the afternoon.

This intersection is located between Old Min bus and Awash primary school, As shown in the figure 3, in the morning peak period the highest traffic volume is occurred in logiya approach, while in the evening peak period the highest traffic volume is occurred in samara approach. But in this station many vehicles are conflicting when there are no traffic police in the area due to street trade found at the intersection.

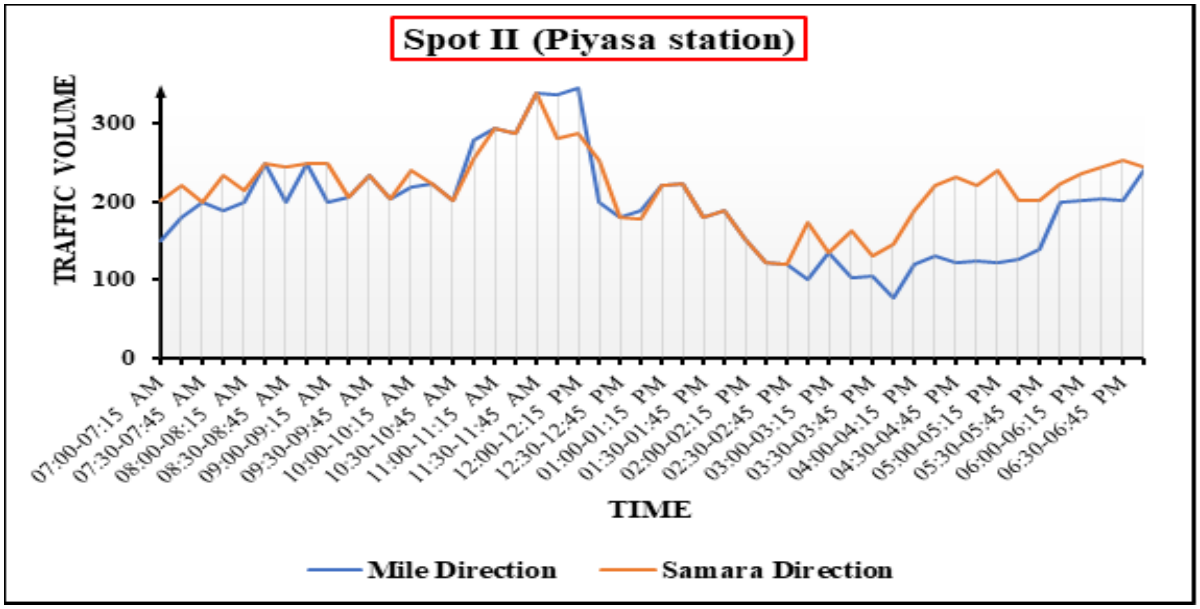

Figure 3 Traffic hourly volume at Spot II (Piyasa Station)

Traffic Volume Analysis at Spot III

This spot is in front of Nazirite Hotel station, and it has the highest traffic volume towards both approaches in the midday peak period and it has also the highest traffic volume in the afternoon.

As shown in figure 5, in the morning peak period the highest traffic volume occurs in logiya approach, while in the evening peak period the highest traffic volume occurs in samara approach. But in this station many vehicles are conflicting when there are no traffic police in the area due to street trade found at the intersection. The maximum traffic volume occurred on logiya approach in the morning peak period while during the evening peak period the highest traffic volume occurred on samara approach.

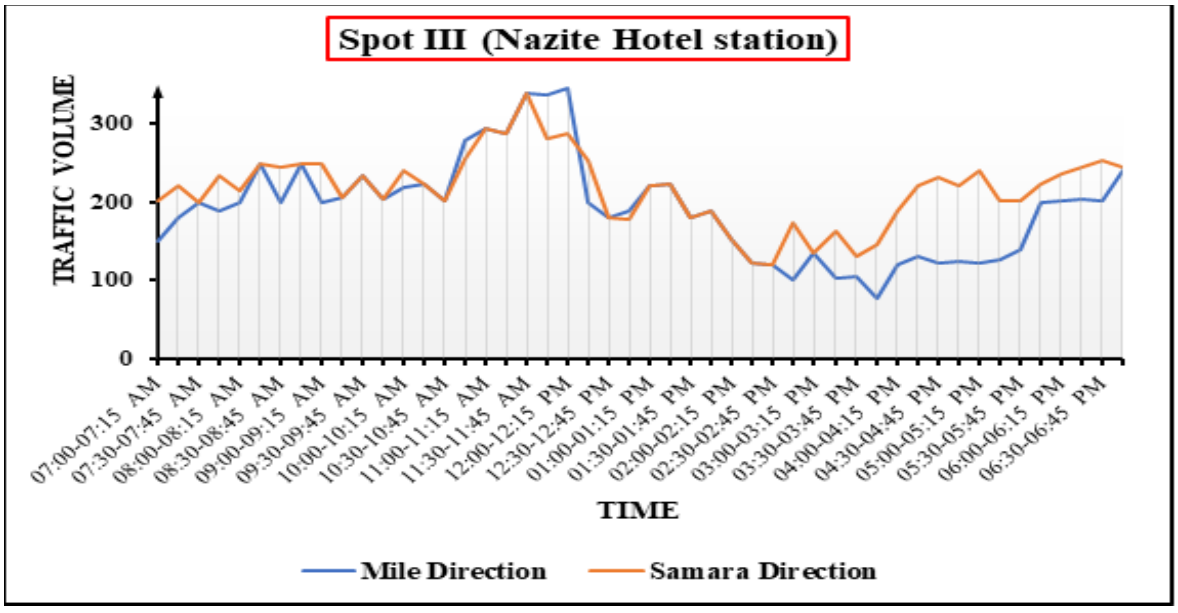

Figure 4. Traffic hourly volume at Spot III (Nazirte Hotel Station)

Accordingly, Level of service analysis is done using VISSIM-23 software at different spot areas with HCM 2010 right-hand rule. Level of analysis for the spot area indicates that most of the intersections are performing above their capacity and have almost LOS-E at spot II which indicates vehicles are moving at extremely low speeds, the occurrence of high delays, and high volumes. Table 3 below presents the Level of service results obtained from VISSIM-23 software.

Table 3 Level of service of each movement, Source: VISSIM-23, 2023

TIMEINT	MOVEMENT	LOS(ALL)
0-3600	1-1: semera to logiya Road@129.1-1: semera to logiya Road@215.4	LOS_C
0-3600	1-1: semera to logiya Road@129.1-3: old minbus station road @38.6	LOS_C
0-3600	1-2: logiya to semera Road@1036.4-2: logiya to semera Road@1127.3	LOS_A
0-3600	1-2: logiya to semera Road@1036.4-3: old minbus station road @38.6	LOS_D
0-3600	1-4: old minbus station road @36.6-1: semera to logiya Road@215.4	LOS_F
0-3600	1-4: old minbus station road @36.6-2: logiya to semera Road@1127.3	LOS_F
0-3600	1-9: semera to logiya Road@129.1-9: semera to logiya Road@215.4	LOS_A
0-3600	**Old Mini-Bus Station /Spot I/**	**LOS_C**
0-3600	2-1: semera to logiya Road@389.6-1: semera to logiya Road@444.4	LOS_C
0-3600	2-1: semera to logiya Road@389.6-5: piyasa station@18.6	LOS_E
0-3600	2-2: logiya to semera Road@802.9-2: logiya to semera Road@861.3	LOS_E
0-3600	2-2: logiya to semera Road@802.9-5: piyasa station@18.6	LOS_F
0-3600	2-6: piyasa station@54.8-1: semera to logiya Road@444.4	LOS_F
0-3600	2-6: piyasa station@54.8-2: logiya to semera Road@861.3	LOS_F
0-3600	2-9: semera to logiya Road@389.6-9: semera to logiya Road@444.4	LOS_A
0-3600	**Piyasa Station/Spot II/**	**LOS_E**
0-3600	3-1: semera to logiya Road@1129.2-1: semera to logiya Road@1206.6	LOS_A
0-3600	3-1: semera to logiya Road@1129.2-7: Naziret hotel station@23.2	LOS_A
0-3600	3-2: logiya to semera Road@39.8-2: logiya to semera Road@118.2	LOS_B
0-3600	3-2: logiya to semera Road@39.8-7: Naziret hotel station@23.2	LOS_C
0-3600	3-8: Naziret hotel station@106.6-1: semera to logiya Road@1206.6	LOS_F
0-3600	3-8: Naziret hotel station@106.6-2: logiya to semera Road@118.2	LOS_F
0-3600	3-9: semera to logiya Road@1129.2-9: semera to logiya Road@1206.6	LOS_A
0-3600	**Nazirate Hotel /Spot III/**	**LOS_C**

Analysis of Capacity

The formula for finding out capacity as per HCM 2010 is

C=1000V/S

Where c= capacity of the road

V=Speed of vehicles

S=Space headway

In this research, it is found that the average speed of vehicles is 24.71 kmph.

Space headway is calculated from density. The average density of vehicles is 60.

Therefore,

S=1000/60= 16.66

Capacity of road C=1000*24.71/16.66= 14.83 say 1500 vehicles / lane/ hour

The volume to capacity ratio is 1610/1500 =1.07 which indicates severe congestion. (Table 2)

ANALYSIS OF SOCIO_ECONOMIC PARAMETERS

The aim was to include all respondents with consideration of gender. The study was to cover about 400 respondents who participated through questionnaires. Out of the total respondents, about 69.0 percent were male and 31.0 percent were female. The observed variation in gender is 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 analysis of traffic congestion in Logiya town. There are five age categories that the respondents' ages might be divided into: Generally speaking, the study intended to involve 400 participants who answered questionnaires. The ages covered are displayed below: About 3.0 percent of the population was under 20, 29.0 percent was between 20 and 30, 30 percent was between 40 and 50, 21.0 percent was between 40 and 50, and 17.0 percent was above 50. The proportion of educational level given below the chart is divided into four groups in order to determine participation in the questionnaires for this research. As we can see, the majority of respondents were in the 17 percent degree and above, 30 percent diploma, 32 percent grade twelve complete, and 12 percent other level ranges. To focus on the issue and provide an analysis of traffic congestion's reality, it is crucial to do this.

Table 4. Sociodemographic Information (Source: Field Survey, 2023)

Questioners		**Frequency**	**Percent**
Gender	Male	276	69
	Female	124	31
age group	Below 20	12	3
	20-30	116	29
	30-40	120	30
	40-50	84	21
	Above 50	68	17
Education level	Degree and above	68	17
	Diploma (10+2)	120	30
	Grade twelve complete	128	32
	Below Grade 12 Other	84	21

According to the analysis, as shown in Chart 1, Fridays account for 43.37% of all traffic congestion. It is very high on Friday due to working trips. It is the last working day, so people come home from workplaces.

CONCLUSIONS

Out of 400 individuals surveyed, the distribution of respondents was as follows: 23% identified as drivers, 32% as passengers, 35% as walkers, and the remaining 10% as cyclists. Notably, 60% of travelers are aged between 20 and 40 years. Regarding education, 39% of commuters have completed their 12th standard. Additionally, 64% of all trips made are classified as working trips. A significant 83% of respondents believe that traffic congestion arises from the excessive number of vehicles using a single road.

The average speed of vehicles in the area is recorded at 24.71 km/h, with a peak hour volume of 1610 Passenger Car Units (PCU) per hour. Traffic volume from Logiya to Semera town is notably high during the morning hours, as individuals travel to the town center for work and business activities. Conversely, traffic volume from Semera to Logiya is heavily congested, particularly during the mid-day peak period, which experiences the highest traffic volume.

Congestion also occurs at Location II (Piyassa) during mid-day, especially when traffic police are absent for various reasons. Socio-economic data indicates that working trips are the primary contributors to traffic congestion each morning and evening. Furthermore, it was observed that trucks are more responsible for traffic congestion than other vehicle types.

To address this issue, an immediate solution is to reroute heavy vehicles, such as trucks, via a bypass road during the daytime, prohibiting their entry into the town.

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