The impacts of improper curbside parking on traffic flow in semi-urban area, Ethiopia

Fikedu Rage Faye[1*], *Abdurrahman Mohammed* Kelecha[1], *Abdugani* Rakhmatov[2], *Shuxratbek* Mannobboyev[3], *Jamshid* Abdunazarov[4]

[1]Department of Civil Engineering, Mettu University, Mettu, Ethiopia
[2]Department Power Supply and Renewable Energy Sources, National Research University TIIAME, 100000 Tashkent, Uzbekistan
[3]Andijan Machine-Building Institute, 56 Bobur Shox Ave, Andijan 170119, Uzbekistan
[4]Jizzakh Polytechnic Institute, 130100 Jizzakh, Uzbekistan

Abstract. Introduction: For many towns in Ethiopia, traffic management is a crucial concern to accommodate the increased number of vehicles per day. Curbside parking is one of the traffic problem experience in Arba Minch town, especially in the midblock commenced at Sikella market to Gamo Square. This area is one of the central business district areas of Arba Minch Town that experience parking problems.
Objective: The study was initiated to investigate the impacts of curbside parking on the traffic flow of the semi-urban area. It was aimed at identifying the cause of curb-side parking and evaluating the parking duration of vehicles.
Methods: Various methods were used to accomplish the study. The data needed for the study were; Number of parking vehicles, duration, parking attraction, the length of curbside that is used for parking continuously, parking pattern and composition of parking vehicles investigated and the geometry of the road has been done by direct field observation. Interviews were also conducted with the owners of the businesses located beside the selected road. To show the change in the traffic flow which occurred due to the existence of curbside parking, traffic volume, and speed study has been also done.
Results: From the collected data, the reason for continuous parking in the study area was identified. These main reasons were the availability of recreational centers and surrounding business activities. The average number of parking vehicles along 120m long curbside which is used for continuous parking was obtained to be 16 vehicles. The parking pattern shown in the area was irregular which leads to accidents and traffic conflicts. The minimum duration of parking was 10 minutes, whereas the maximum was more than 2 hours. Because of the lack of work and climate conditions, most vehicles were parked in the midmorning and midafternoon. Most drivers were volunteered to use off-street parking if it provided. Using the traffic volume and speed study, the capacity of the road is estimated to be 140 vehicles per hour. Finally, the level of service on the road was determined for every 30 minutes.

1. Introduction

The lack of hard data regarding parking capacity and the use of parking makes it difficult to fully understand the real problem and develop effective policies. Compared to other subjects concerning transport and mobility our knowledge about parking, the problems that arise from parking, and the exact effects of parking policy is quite limited [1]. Thus it is difficult to develop effective parking policies. Some of the problems associated with on-street parking are as follows; Congestion, Accident, Environment pollution, and Obstruction to the traffic flow, traffic flow is a complex phenomenon. The basic flow characteristics of a roadway are Speed, Capacity & Level of Service (LOS) which are inter-related and depend on various factors affecting it [2].

Due to increasing in people's movement, traffic flow nowadays is becoming very high. The day-to-day increase in traffic flow results from many traffic problems. In the road transportation system, the common problem is congestion, accident, loss of energy, increased traffic delay, and traffic time. These problems may cause by various reasons and curbside parking the one. Curbside parking is caused due to improper planning and implementation of parking policy.

*Corresponding author: fikedu.rage@meu.edu.et

Arba Minch City is having been facing this parking problem as there is an increase in vehicle ownership but less rate of parking facilities. Curbside parking problems in Arba Minch City particularly on Sikella Road are mainly caused by the absence of off-street parking, improper planning of the city, negligence of drivers, and roadside activity. Curbside parking will consequence accidents, environmental pollution, increased traffic congestion, traffic delay, travel time, and travel cost.

The debate regarding the merits and drawbacks of on-street parking stem from a lack of research surrounding the subject over the last two to three decades [3]. The utilization of on-street parking is considered to be a more efficient use of land as it limits the need for off-street parking and access points to properties adjacent to major arterial roads [4]. This aspect of on-street parking also reduces costs for businesses, maximizes land utilization, and creates a pedestrian-friendly environment for the community by delineating vehicles and land use. Extending from this concept it is believed to improve pedestrian safety by providing a barrier between the flowing traffic and the footpath as well as reducing the speed of vehicles traveling on the roadway [5].The role and impacts of curb parking on traffic flow and safety have been extensively studied over the last century. Most studies, however, were done before the 1980s, and there have been relatively few more recent studies.

This study aims to identify the consequences of curbside parking on the level of service and urban areas, particularly Arba Minch town.

2. Materials and Methods

Study Area

Arba Minch (Amharic: □□□ □□□, "forty springs") is a city and separate woreda in the southern Regional state, of Ethiopia; the first common name for this city was Ganta Garo. Located in the Gamo Gofa Zone of the Southern Nations, Nationalities, and Peoples Region about 500 kilometers south of Addis Ababa, at an elevation of 1285 meters above sea level. It is the largest City in Gamo Gofa Zone and the second town in SNNPR next to Awassa. It is surrounded by Arba Minch Zuria woreda (Figure 1).

Fig. 1. Study Area

Data Collection and Survey Method

The characteristics parameters such as speed and volume study data are conducted which was conducted. The interview was also collected with business owners beside the curbside and vehicle drivers to address the issues regarding the parking situation and its influence. Number of parked vehicles is shown in Table 1.

Table 1. Number of Parked Vehicles

Time	Bajaj	Taxi	Truck	Parked
8:00-8:30	2	4	0	6
8:30-9:00	8	5	0	13
9:00-9:30	12	6	1	19
9:30-10:00	22	5	0	27
10:00-10:30	20	6	2	28
10:30-11:00	21	7	2	30

Attraction of curb side parking
Availability of off-street parking facility: by direct observation of the area, there is no off-street parking near the street and proper curbside parking facility which results in the drivers parking their vehicles on the outer side of the road. Adjoining land use activity of the street data: Data that are recorded by observing the study environment. The economic activities that are done at the side of Sikella midblock attract people to park their vehicles are; Shopping, Offices, Hotels, Recreational centers, and Banks.

a. Traffic Volumes

The enumerator is standing near the reference line and records the vehicles while crossing the reference lines regarding categories. The recorded traffic volume along the three midblock was;

b. Traffic peed
c. Obtain Appropriate Study Length
d. Interview

The other interview gathered is from the drivers of the vehicles. The interview instrument was organized to incorporate questions regarding the causes of parking, the reason for preferring the study area, the duration of parking, the time of the day for parking.

3. Results and Discussion

Throughout the day, several vehicles used the selected street for parking purposes. The extent of parking was variable within various periods of the day. The parking trend is high from 9:00-11:00 am and 2:00-4:00 pm. There were few vehicle compositions in the parking trend. Bajaj is the dominating vehicle. The total parked vehicle volume was 299 vehicles. The parked volume was composed of 74.58% Bajaj, 23.07% taxis, and 2.34% truckers (Figure 2). The average parked volume per each 30 minutes was 16.

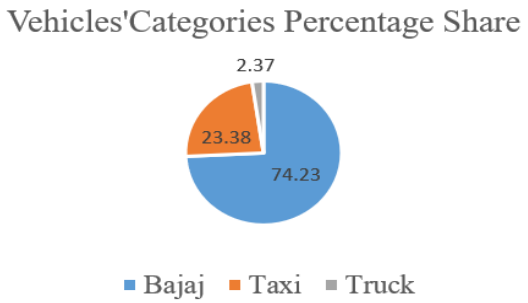

Fig. 2. Composition of Parked vehicles

Interpretation of interview
The response obtained from the interview was interpreted in accordance with the objective carried out and using a simple statistical analysis. Business owner responses for the questionnaires, Influence of curbside parking and Drivers response are shown in Figures 3, 4 and 5.

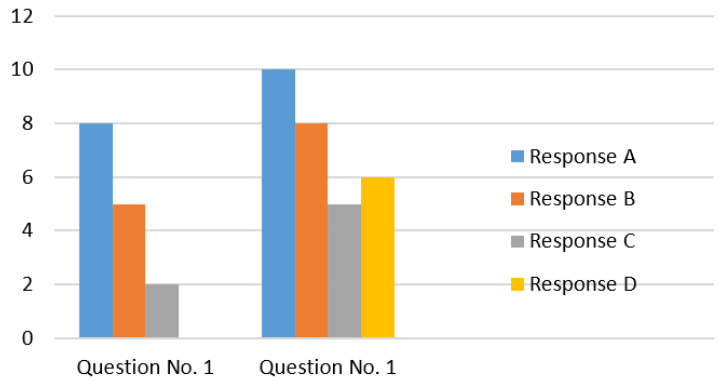

Fig. 3. Business owner responses for the questionnaires

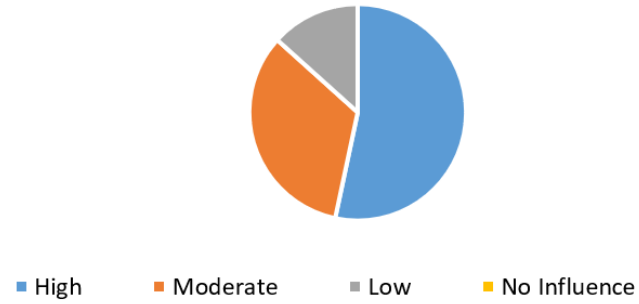

Fig. 4. Influence of curbside parking

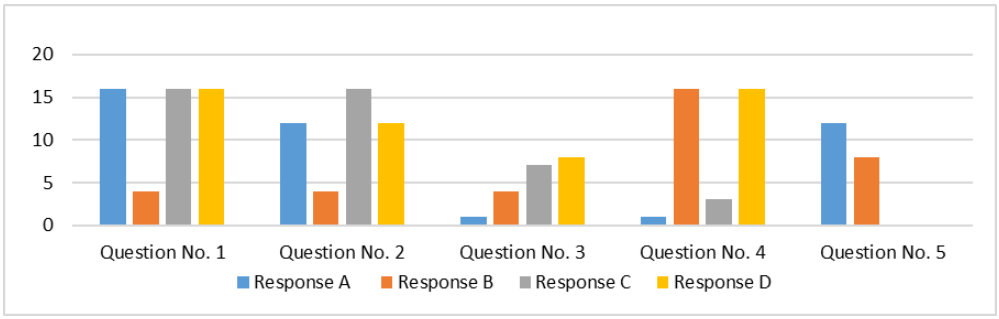

Fig. 5. Drivers response

Level of service (LOS) determination

LOS is used to analyze highways by categorizing traffic flow and assigning quality levels of traffic based on performance measures like speed, density, etc. In order to determine the LOS of a road, the capacity of the road and the traffic volume of the road are required (Figures 6, 7 and 8).

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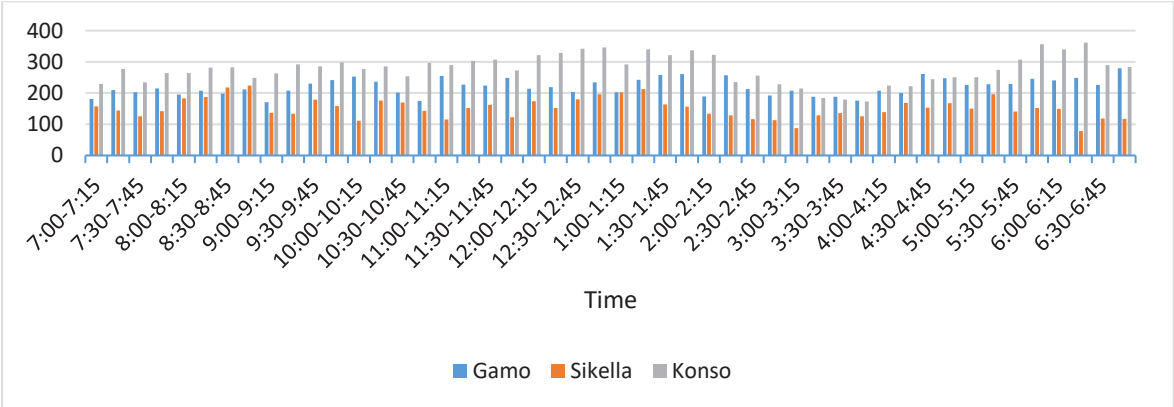

Fig. 6. Total Vehicles in PCU per 15 minutes

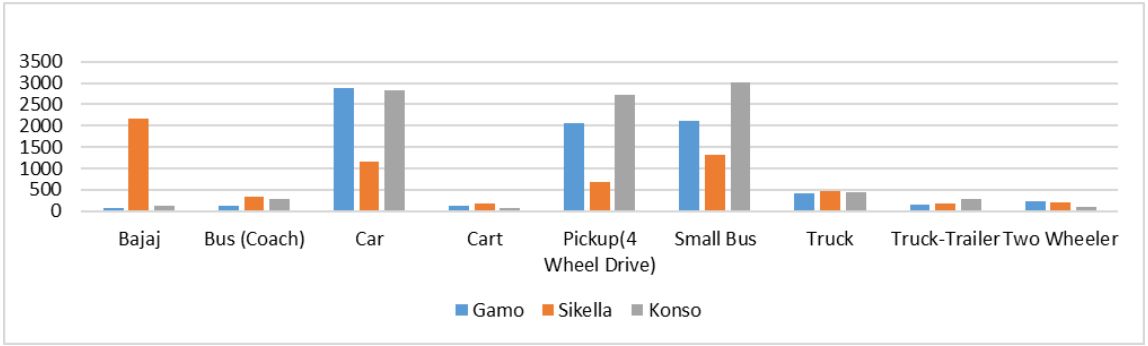

Fig. 7. Total traffic volume in PCU

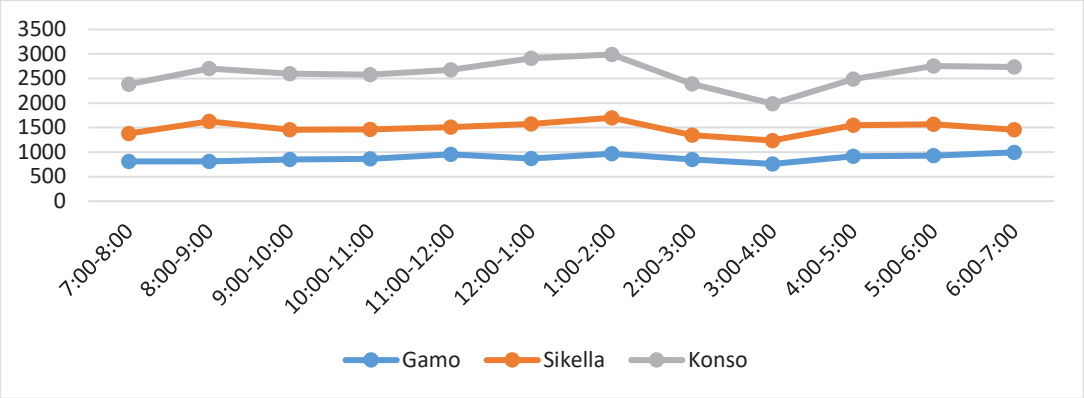

Fig.8. Stream Volume Per hour

Capacity calculation

Capacity is defined as the maximum number of vehicles, passengers, or the like, per unit of time, which can be accommodated under given conditions with a reasonable expectation of occurrence.

Speed calculation

Since the important data necessary for speed calculation which is the time elapsed and the distance traveled were recorded, speed calculation was done by dividing the traveled distance by the elapsed time. The calculated speed for each vehicle and the average speed is shown in the table illustrated below (Table 2).

$$V = \frac{S}{tf - ti}$$

Where S = distance covered (30m)

t_f =Ending time

t_i =starting time

Table 2. Basic Statistical Properties of Speed of Konso Midblock

Basic Statistical Properties of Speed of Konso Midblock						
	Minimum	Maximum	Mean	Median	Std. Deviation	Variance
Bajaj	20.54	38.40	28.26	27.86	3.92	15.35
Bus	20.34	39.71	28.80	28.92	4.19	17.58
Car	7.49	45.38	31.78	31.22	7.06	49.90
Cart	15.79	45.00	26.77	27.07	6.00	35.99
Pickup(4 wheel drive)	22.78	41.86	30.50	30.26	3.78	14.31
Small Bus	25.09	48.00	33.29	33.03	4.31	18.56
Truck	21.22	39.71	27.35	27.17	4.11	16.92
Truck-Trailer	15.00	24.43	20.01	20.04	2.38	5.68
Two Wheeler	22.84	45.69	31.63	30.77	5.20	27.07

PCU (Passenger Car Unit) calculation

The passenger car unit (PCU) value of each class of vehicles is the prime importance in the study of mixed traffic flow. It is a conversion factor that is used to equivalence any type of vehicle into passenger car unit (the same unit) (Figure 9).

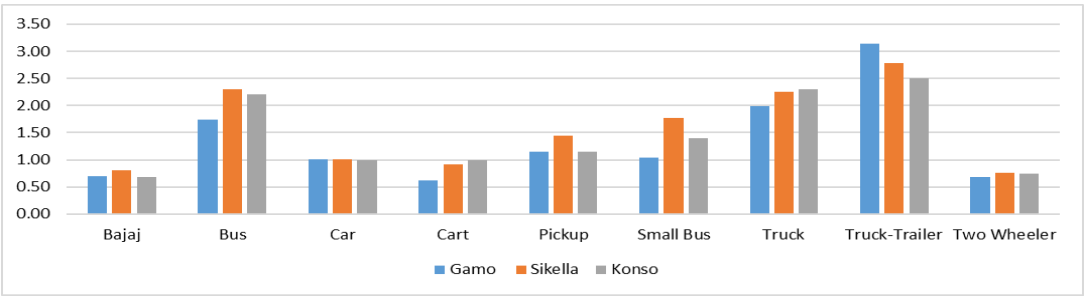

Fig. 9. Estimated PCU values for 3 midblocks

Table 3. Total Traffic Volume in Stream

Total Traffic in Volume of Stream			
	Total Vehicles in PCU Per 15 Minutes		
Time	Gamo	Sikella	Konso
7:00-7:15	181	157	229
7:15-7:30	210	144	277
7:30-7:45	202	126	235
7:45-8:00	215	142	264
8:00-8:15	195	183	265
8:15-8:30	207	188	282
8:30-8:45	198	218	283
8:45-9:00	212	224	249
9:00-9:15	170	137	263
9:15-9:30	207	134	292
9:30-9:45	230	179	286
9:45-10:00	241	158	298
10:00-10:15	253	111	277
10:15-10:30	236	176	285
10:30-10:45	201	170	253
10:45-11:00	174	143	297
11:00-11:15	254	115	289
11:15-11:30	227	152	303
11:30-11:45	224	163	307
11:45-12:00	249	122	273
12:00-12:15	214	173	322
12:15-12:30	219	152	329
12:30-12:45	203	180	342
12:45-1:00	235	196	346
1:00-1:15	203	203	291
1:15-1:30	243	213	340
1:30-1:45	258	164	322
1:45:2:00	261	156	337
2:00-2:15	190	134	322
2:15-2:30	257	128	235
2:30-2:45	213	116	256
2:45-3:00	193	114	228
3:00-3:15	207	87	215
3:15-3:30	189	129	184
3:30-3:45	188	136	179
3:45-4:00	175	125	173

The counted traffic volume was converted into a passenger car unit by using the PCU conversion factor by multiplying the PCU factor of each vehicle type with its respective volume. The terrain type of the study area is flat/level. For this reason, the level terrain PCU value is used for this study. Hence, using the conversion factor shown in the Table 3 below, the different type of vehicle volume was converted into passenger car unit as shown above:
Figure 10 is oriented to show frequency (Number of Vehicles moving with corresponding speed) on the X axis and to show the average speed of vehicles on the Y axis. Then The Scattered points obtained were joined by a smooth curve and extended up to Y- the axis at one end and x- the axis at another end. The point where the extension of the curve line touches the Y- axis indicates the Free Flow Speed. The volume corresponding to half of the free flow speed gives the Capacity of the road.

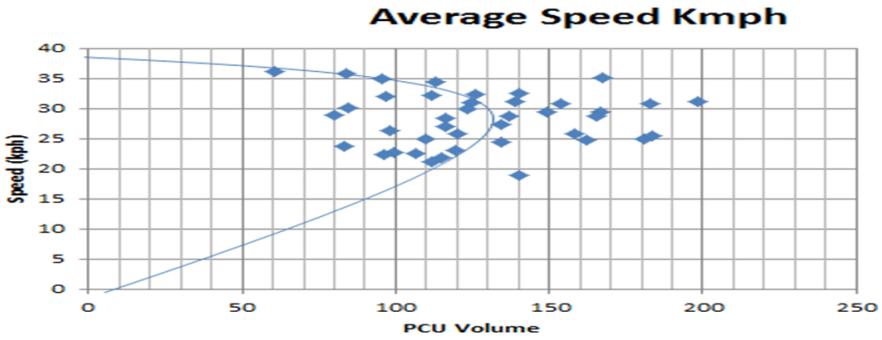

Fig. 10. Road Capacity Curve

From the above road capacity curve, the free fall speed of the road is 40 km/h. the free fall speed rarely occurred only when there are very few vehicles on the road. The capacity of the road to carry a maximum number of vehicles with maximum travel speed is determined to 140 vehicles. Hence the capacity of the road in the study area is 140 vehicles. Which means it serves 140 vehicles within the lane per hour.
The level of service of the road was determined by calculating the ratio between the PCU volumes versus its capacity. The capacity of the road is the same throughout the road. But, the level of service of the road varies from time to time with its respective PCU volume. As the volume increases, the LOS will be decreased.

The LOS of the road is calculated and listed in the table presented below.

$$LOS = \frac{Volume}{Capacity}$$

Table 4. Sikella Midblock Level of Service

Traffic Volume (V)	Capacity (C)	V/C	LoS
157	**140**	**1.05**	**F**
144	**140**	**0.96**	**E**
126	**140**	**0.84**	**D**
142	**140**	**0.95**	**E**
183	**140**	**1.22**	**F**
188	**140**	**1.25**	**F**
218	**140**	**1.46**	**F**
224	**140**	**1.49**	**F**

The curbside parking influenced the level of service or the traffic flow of the road as depicted in the above table. For instance, the LOS at 9:00-9:15 was C with 100 volumes and 19 parked volumes. The same volume100 but different parked volume 28 at 10:00-10:15 had LOS of D.

4. Conclusion

Using the data collected by various methods, analysis has been executed that helped to conclude the findings. The length of the curbside which is used for parking continuously was 120m. Along this distance, the average parking

volume was 16 vehicles per 30-minute parking duration. Of which, 74.58% was Bajaj, 23.07% was a taxi and 2.34% was a truck. Of 15 business owner who was interviewed, 8 people believed that curbside parking has a high influence on their business. The vehicle drivers responded that the main reasons for selecting the study area for parking were the availability of shadow and recreational centers. Among 20 vehicle drivers, 16 of them said that the attraction for parking was the availability of parking space and recreational centers, their duration was more than 90 minutes, and most drivers park their vehicle mostly from 9:00-11:00 pm and 2:00-4:00 am. All drivers volunteered to use off-street parking if it was provided. The capacity of the road was determined to be 140 vehicles per width of the lane within one hour.

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