
Assessment of the Impact of Urban Public Transport Terminals on Traffic Speed in Shashemene, Ethiopia

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This paper discusses the impact of urban public transport terminals up on traffic speed in Shashemene City. A study is conducted in Shashemene city, Ethiopia at two bus station locations namely Awasho bus station and Arada bus station to observe the variation of traffic speed for different existing traffic conditions. Shashemene is one of the major cities in Ethiopia. Both bus stations are located in the influential areas of Shashemene city. A taxi/Auto rickshaw stop exists on the kerb side beside each of the bus stations. The width of the road is getting affected due to the occupancy of taxi/auto rickshaw stand at the kerb side and is varying from time to time. Huge volume of pedestrians will be crossing the road continuously from one side to the other side to catch the bus at the bus stations. The location of bus stations is so complicated and are suffering the through traffic speed with the impacts of bus movements, taxi movements and pedestrian crossings.

Keywords: Traffic Speed, Traffic Volume and Bus Frequency.

Traffic data is collected near both the bus stations through the method of manual data collection by enumerators to assess and evaluate the impact of urban public transport terminals on traffic speed. A multiple non-linear Regression Model is developed to analyze the variation of traffic speed for various bus frequencies, taxi frequencies, pedestrian crossings and effective road widths which will determine the individual effect of urban public transport terminals up on other traffic flows in Shashemene city. Many charts and cases under different traffic scenarios at both bus stations is developed. The results obtained from the model shows that under high impact of traffic condition over 15 km/hr is unexpected at Arada bus station even if traffic volume is restricted to 100 vehicles on 14m effective road width. Finally, three alternatives are proposed to improve the existing traffic condition.

Introduction

Transport terminals are an important infrastructure of public transportation where buses and taxis stop to pick up or drop passengers. It is center and intermediate location where freight and passengers either originates, terminates or is handled in the transportation process.

In developing countries particularly in Ethiopia, the number of taxis known as Auto rickshaws is extremely increasing in the town areas. This is because in urban areas, peoples are densely populated as compared to rural areas. Moreover, the need of transportation is also high as peoples living in the city accomplishes more of their work activities within the city. This was forced the other transportation in the city and get impacted by this taxi as they park on the road.

Shashemene city is one of the principal towns in Southern part of Ethiopia. The town lies on the Trans-African Highway 4 Cairo-Cape Town, about 250km from the capital, located on latitude of 70 12' north and longitude of 380 36' east. The total population in the town is 246,774(without including recently included kebeles from rural areas in case of new master plan), with almost all equal ratio of male and female. Shashemene has five major corridors to which its road connects to its neighbor towns/cities.

Traffic flows in Awasho, Abosto and Arada sub cities are the major traffic flows where high traffic problems occur in the city as compared to the other sub cities' traffic flows. Bus station and taxi/Auto rickshaw terminals abundantly exist in these sub cities. Among them, Awasho and Arada bus stations are the two major bus stations and numerous taxi stops are available in the city. Awasho bus station is larger as compared to Arada bus station and exists at the intersection side of Addis Ababa to Kenya international roadway and Shashemene to Bale Robe roadway. This makes the city busier by transportation especially around market centers. That is why the urban roads are becoming more congested.

Urban taxis/Auto rickshaws which were pulling over and picking up passengers in the city causes traffic problem on traffic flows. It usually makes traffic congestion and delays on urban roadways with high traffic volume, especially in sections near bus stops where passenger transfers occur. A passenger would also step into traffic lanes to get or leaving a taxi often posing safety concerns.

Statement of the Problem

In urban areas the speed of vehicle is affected by various factors. Among many factors, effective width of road, existence of pedestrians on roadway, traffic density, any obstruction on roadway, presence of roadside bus stations and taxi stops, road side parking, roughness of road ways are major contributors.

Accordingly, in Shashemene town, the roadside bus station and taxi stops have significant influence on nearby traffic flows. As result of disturbance in vehicle travel speed, the road nearer to bus station and taxi stops are not delivering the required service in its design period of time and the roadway capacity become reduced as a result of taxis, pedestrians and buses stop on the road way which then reduces the effective road width.

Different vehicles in the town moves along urban street of road in transporting goods and people in the urban. Therefore, both freight vehicle and public vehicles are get congested, delayed and traffic flow speed of vehicle obstructed. In addition, the taxi stops, bus stations were located and constructed beside the intersection of two major roads of high traffic volumes in the cities so as the vehicles like minibuses taxis and rickshaws park at the edge of these urban roads.

There are no strict actions by traffic policies to pedestrian crossing without Zebra crossing to get bus or taxis which is again able to affect the movements of vehicles. As a result, the capacity of roadway designed for a given vehicles nearer to bus and taxi stop stations got reduced. For this regard, this thesis is devoted to study the impact of urban public transport terminals affecting nearby traffic flows in the city.

Objectives of the Study

- To evaluate the impacts of road side bus stations on traffic speed.
- To assess the effects of taxi stops and pedestrian crossing on other mode of vehicles.
- To analyse the extent of speed reduction suffered by different types of vehicles due to the location of bus stations.
- To develop multiple regression model that represents how much traffic speed is impacted due to the existence of urban public transport terminals on the side of the main road.

Significance of the Study

This study will be useful to search some possible alternatives at the bus station location to improve the traffic conditions. An evaluation on the impact of different bus stations and taxi stops on the operations of traffic speed can provide useful information to the city planners for the design of bus stops under different traffic and environmental conditions.

On the other hand, the expected benefit of this research is also to provide information and enable someone who are responsible to locate the stations of terminals to make better decision while planning to have less effects up on traffic flow so that traffic movement on the roads has not affected more. Furthermore, the research helps for the responsible authorities to see the effect of how severe the issue is, such that great attention and participations on any research based on urban terminal effects on nearby environment related problems will be supported efficiently. As it was stated earlier, road traffic congestion around urban public terminals have been increasing from time to time. However; no attention is given to identify the root cause of the problem and its solutions in Shashemene town. Hence, the findings of this study help:

The Practitioners (traffic police and road and transport officials) to be aware of the problems, because as a practitioner, they can contribute on their own part in reducing the impact of urban terminals on road traffic.

To give a brief back ground and detail of existing traffic characteristics in Shashemene town which is especially a clue in forecasting future Average Annual Daily Traffic (AADT) from existing condition. The study is believed to enrich the existing literature on Shashemene town public terminals impacts on traffic flow around it. To inform the existing situation so that practitioners able to think over the future scenarios. To give effective ways of recommendations

based on analysis that will be input to strategy and policymakers, transport authorities, road engineers, and other concerned bodies, to take counter measures and monitor road traffic problems due to inappropriate locations of urban terminals.

Literature Review

Bus stops interfere with traffic flow, as the buses stop in the travel lane, resulting in a “bottleneck” which reduces in road width at the location of the stops. Bus bays interfere with passing vehicles primarily while buses maneuver to pull into and out of the stop. They will also interfere with vehicle movement if bus demand exceeds the bay’s capacity, resulting in some buses waiting in the travel lane until the buses occupying the bay exit the bay (R. Z. Koshy and V. T. Arasan, 2005).

A study was conducted on the effect of capacity by means of lane width of roads in varied traffic conditions. It was concluded that the rate of decrease in speed with traffic volume is different for different types of vehicles. Further it is expressed that the effect is more for three wheelers and heavy vehicles than two wheelers (Chandra et.al, 2003).

Similarly, a study was conducted in Delhi to assess the effect of cycle rickshaws on traffic flow. The study was made in different lanes and observed that the impacts of cycle rickshaws are very significant on the speed of the traffic flow of the network as compared to the other factors (Rajat Bose et al., 2004).

Taxis pulling over and picking up passengers is one of the main causes of delay on urban roadways with high traffic volume, especially in sections near bus stops where passenger transfers occur. A passenger would also step into traffic lanes to get a taxi, often posing safety concerns. It is therefore necessary to prevent taxi pick-ups from happening outside of designated taxi stands on roads with busy traffic (B. Mao and H. Chen, 2001).

In Lagos city, a study was conducted and found that road width and passengers on the road creates a major influence resulting in traffic congestion (Olaogbebikan J. E. N.,et. al.,2013).

Methodology

Study Locations

The study was conducted in Shashemene town. Particularly, two major study locations were selected. These are Awasho and Arada bus stations. Awasho bus station is located at very busy place in Awasho sub city. It is situated at one side of four major legged road intersection. Shashemene to Bale Robe and Hawassa to Addis Ababa Road cross each other at this side of bus station. Traffic problems like traffic delay, congestion, conflicts and parking of vehicle on roadway by obstructing traffic flows widely happen in the city.

Congested Traffic Flow at One Side of Awasho Bus Station

Arada bus station: It is older bus station located about 400m away from the main road in Arada sub city. This terminal serves for only small buses (minibus and related). However, since it is located at the side of road linking Taiwan market center as one of cities biggest center, it has high impact on traffic flows.

Data Collection

Two typical urban roadway segments of higher traffic volume in front of each terminal in Shashemene town were selected for data collection. Required traffic flow data was collected at selected 30m wide baselines on given road segments.

Collected parameters highly influence the respective traffic speed. These parameters are spot speed, bus frequency, taxi frequency, pedestrian crossing and effective road widths.

For this study manual method of data collection was adopted and was done in terms of manpower where vehicles are to be classified with a number of movements recorded separately. At selected sites, the traffic on each arm has counted and recorded separately for each movement.

The data collection task comprises six main activities. These are recording the number of bus frequency, taxi (auto rickshaw) frequency, traffic volume, spot speed, effective lane width, and pedestrian crossing for every 15-minute interval from morning 6:00 a.m. up to evening 8:00 p.m. (14 hours) for one day to predict average traffic speeds of flowing vehicles.

Multiple nonlinear regression equation was developed to know how much each independent variables influences the traffic speed of the vehicle. The coefficient of each independent variables considered is determined to visualize the degree of each parameter affecting the dependent variable. The relation between dependent variable (traffic speed) and independent variables (all factors considered that are affecting traffic speed) was finally developed and interpreted.

Observation

It is clearly understood from the collected data that over 80 percent of vehicles affecting the traffic flow are taxis/Auto rickshaws where as the number of other types of public terminal's vehicles contributing traffic flow problems like buses are very less in percentage of composition.

Moreover, pedestrians crossing the road around the bus stations are also very high. Pedestrian major intention around bus station is to get on or away from taxis/Auto rickshaws and buses. It is observed at Awasho bus station that about 30% of pedestrians' crosses to take or leave taxis/Auto rickshaws whereas about 60% of them crosses for taking or leaving buses. Similarly, at Arada bus station of out of all pedestrian crossings about 10% of them are observed to cross for taking or leaving taxis/Auto rickshaws where as 80% of them are observed to cross for getting or leaving buses.

Analysis of Traffic Data

The data collected is first analyzed logically to give good inferences. Without doing more analysis the following relationship between a dependent variable (speed of vehicles) and parameters influencing speed (traffic volume, bus frequency, taxi/auto rickshaw frequency, pedestrian crossing the road and effective road width) has been analyzed. It was observed that Speed of the vehicles shall decrease as:

- Traffic volume increases

- Number of bus frequencies increase
- Number of taxi (auto rickshaw) increases
- Pedestrian crossing road increases
- Effective road width decreases and vice versa.

Development of Multiple Non-Linear Regression Model

As stated earlier, multiple regression is a well-known statistical technique which fits a relationship between dependent and independent variables. The causes of speed reduction of traffic beside terminal can be analyzed with more focus by using the above technique. In this study, Average vehicular speed is taken as a dependent variable and all other influencing factors such as traffic volume (variable 1), bus frequency (variable 2), taxi frequency (variable 3), pedestrian crossing (variable 4) and effective road width (variable 5) are taken as independent variables. A Multiple non-linear regression equation was developed by using the above dependent and independent variables.

The following is the multiple non-linear regression equation for Awasho Bus station site:

$$\text{Average Speed} = 2.703453 - 0.320380 * e^{\text{Vol.}} - 0.189948 * e^{\text{BF}} - 0.063848 * e^{\text{TF}} - 0.292953 * e^{\text{PC}} + 0.268960 * e^{\text{ERW}}$$

$$R^2 = 0.9254; R = 0.9620; F = 9.926; P = 0.02255$$

Table 4.1 Results of Multiple Non-Linear Regression Model for Awasho Bus station

Parameter	t- ratio	P- level
Intercept 1	3.15903	0.034216
Variable 1	-0.92424	0.407670
Variable 2	-0.90770	0.415378
Variable 3	-0.32523	0.761311
Variable 4	-1.41571	0.229793
Variable 5	1.01868	0.365955

It is clearly visible from table 4.1 that p-level value of intercept 1 is less than p-level value of all other variables. This indicates that the nonlinear regression model is real.

Similarly, the following multiple non-linear regression equation was developed for Arada Bus station site

$$\text{Average Speed} = 2.382901 - 0.164449 * e^{\text{Vol.}} - 0.120024 * e^{\text{BF}} - 0.138307 * e^{\text{TF}} - 0.278316 * e^{\text{PC}} + 0.184374 * e^{\text{ERW}}$$

$$R^2 = 0.8442; R = 0.9188; F = 4.3356; P = 0.09012$$

Table 4.2 Results of Multiple Non-Linear Regression Model for Arada Bus station

Parameter	t- ratio	P- level
Intercept 1	2.460788	0.069632
Variable 1	-0.424852	0.692802
Variable 2	-0.361399	0.736082
Variable 3	-0.574529	0.596376
Variable 4	-0.867307	0.434706
Variable 5	0.490306	0.649596

It is again visible from table 4.2 that p-level value of intercept 1 is less than p-level value of all other variables. This indicates that the nonlinear regression model is real.

Results of the Analysis of Multiple Non-Linear Regression Model

In order to understand the severity of each influencing parameters in the study locations, the collected data is considered for different cases and the various graphs are drawn for each case as shown in the figure below. For various conditions and combinations of different influences, about sixty graphs were developed and patterned in to 2 cases for both bus stations. These cases are:

Case 1: When TF = 20, BF = 10, PC = 50 up on changing Traffic Volume, Bus Frequency and Effective Road Width.

Fig 1. Graphs showing TV in number of vehicles per 15 minutes (x-axis) vs. Predicted speed in km/hr. (y-axis) at very low traffic conditions

Fig 1 clearly indicates the influence of each parameter on the traffic speed. It is observed from the graph that at most favorable condition meaning (when BF=10, TF = 20, and PC =50) over 30km/hr, the average travel speed in urban area of road section beside Awasho bus station will be met if the traffic volume is restricted to only 100 vehicles per 15 minute and effective road width is not less than 5m. But it should be no interrupt at Arada bus station for the same scenarios.

Case 2: When BF = 30, TF = 100, PC = 200 up on changing Traffic Volume and Effective Road Width.

Fig 2. Graphs showing TV in number of vehicles per 15 minute (x-axis) vs. Predicted speed in km/hr. (y-axis) at very high (worst) traffic conditions Similarly, It is observed from figure 2 that the influence of traffic volume of each terminal on travel speed of vehicles up on different traffic scenarios at most worst condition (meaning when BF = 30, TF = 100 and PC = 200) over 20 km/hr, the average travel speed in urban area of road section beside Awasho bus station in Shashemene town is unexpected if traffic volume is restricted to only 100 vehicles per 15 minute even if the effective road width is as wide as 14m, whereas over 15km/hr speed, it is not met at Arada bus station even if effective road width is as wide as 12m.

Alternatives Proposed to Improve the Traffic Speed at each Bus Station

In order to reduce the impact of Shashemene urban public transport terminals on traffic flow, recommendations are made based on the analysis carried out. This impact reduction is described in terms of traffic speed improvement. Three alternatives for each bus station are proposed to implement.

Alternative 1: proposed to shift the bus station from the existing location to any arterial road. It is observed that out of all pedestrian crossing, about 60% to 80% of pedestrians at Awasho and Arada bus station respectively are going to bus station. Therefore, by shifting the bus station, the impact of bus frequency will be reduced completely and 60% to 80% impact of the pedestrian crossing will be reduced at each bus station.

Alternative 2: proposed to shift the taxi/auto rickshaw from the location of bus station to any other road. This will reduce the impact of taxi frequency completely at each bus station location. About 30% of the pedestrians at Awasho and 10% of pedestrians at Arada bus station are observed to cross the road for taking and leaving the taxi that will also be reduced.

Alternative 3: Proposed to erect an over bridge at each bus station for the pedestrians to cross the road from one side to the other side assuming that 60% to 75% of the pedestrians use the over bridge at Awasho and Arada bus station respectively. This will reduce the respective impact of pedestrian crossing at both bus stations. For each alternatives made, predicted speed got improved. Thirty-two cases were developed to observe the degree of speed improvement for each alternative at each bus station.

Fig 3. Graph showing the relationship between predicted speed of existing traffic condition and recommended alternatives for different cases at Awasho bus station.

Fig 4. Graph showing the relationship between predicted speed of existing traffic condition and recommended alternatives for different cases at Arada bus station. From the above two graphs, it is clearly understood that predicted speed for each alternative vary in improving the existing traffic speed. Alternative 1 will improve the traffic flow by 4 times the current speed. Alternative 2 will double the existing traffic speed and Alternative 3 will similarly improves the existing speed.

Summary and Conclusion

The study is conducted to assess the impact of urban public transport terminals on traffic speed in Shashemene city of Ethiopia. A detailed survey is conducted to collect the traffic data manually. Travel speed and other five identified impacting parameters such as bus frequency, taxi frequency, pedestrian crossing, traffic volume and effective road width are collected for 14 hours (6:00 a.m to 8:00 p.m). The data collected is sorted out in different forms to understand the severity of the speed in different locations of the town. It is observed that over 80 percent of the vehicles in the traffic flow are getting affected by taxis/Auto rickshaws. More traffic flow is again observed to exist at Awasho bus stations as compared to Arada bus station.

A Multiple Non-Linear Regression equation is developed to estimate the influence of each parameter on traffic speed. Traffic speed is taken as a dependent variable and all other influencing parameters are taken as independent variables. From the analysis, it is concluded that the influence of traffic volume at Awasho bus station and the influence of pedestrian crossings at Arada Bus station are more predominant factors affecting the traffic speed in Shashemene town followed by road defects. The influence of taxi frequency and bus frequency at Awasho and Arada bus stations respectively are found to be minimal.

From the survey analysis, it is concluded that the dominating factors for speed at Awasho and Arada bus stations are traffic volume (28.32%) and (18.18%), bus frequency (16.81%) and (13.64%), taxi frequency (5.31%) and (15.91%), pedestrian crossing (25.67%) and (31.82%), and effective road width (23.89%) and (20.45%) respectively.

Recommendations

From the analysis carried out, three alternatives are proposed to improve the traffic speed at Awasho and Arada bus stations. Among them, the Alternative-2 i.e. shifting the taxi/Auto rickshaw from the location of the existing bus station to any other road will double the existing traffic speed. Seeing at cost and simplicity of implementation, it is recommended to implement Alternative- 2 at each bus station.

Reference

- H. Kim, J.-S. Oh, and R. Jayakrishnan, (2005) “*Effect of taxi information system on efficiency and quality of taxi services,*” *Transportation Research Record*, no. 1903, pp. 96–104.
- B. Mao and H. Chen, (2001) “*Sustainability analysis of Chinese transport policy,*” *The International Journal of Sustainable Development and World Ecology*, vol. 8, no. 4, pp. 323–336,
- Zhang, G. K., Rajesh, E., & Reddy, W., (2014). *The Influences of Various Types of Bus Stops on Traffic Operations*. *International Journal of Civil Engineering and Technology*, 2(4), pp 73-81.
- Chethan, N. T., & Rajendra, K, (2015). *Impact of road side bus stops on capacity of roadway*. *IJESRT*, 2(3), pp 147-157.
- Sai, C., & Satish C. (2014). *Impact of bus stop on urban traffic characteristics: a review of recent findings*. *Journal of Society for Transportation and Traffic Studies*. 5(2), pp 57-72.
- R.Z.Koshy and V.T.Arasan (2005). “*Influence of bus stops on flow characteristics of mixed traffic,*” *Journal of Transportation Engineering*, vol.131, no.8, pp.640–643.
- Reddy R., Rao S.N., Rao C.R. (2008), “*Modeling and evaluation patterns on the impact of on-street parking in reference to traffic mobility*”, *Journal of Indian Roads Congress*, Vol. 69 (1), pp101 – 109.

Raju Ramesh Reddy (July-August, 2017) “*Evaluation of Rate of the Reduction in Road Capacity at Kerb side Bus Stop in Urban areas under Mixed Traffic conditions – a case study in Hyderabad city*” Journal of Mechanical and Civil Engineering, Vol.14(4), pp1-8

Satish Chandra and Upendra Kumar (March/ April 2003), “*Effect of Lane width on Capacity under mixed traffic conditions in India*”, Journal of Transportation Engineering, Vol. 129 (2), pp155- 160

Cambridge Systematics, Inc. and Texas Transportation Institute, (July 19, 2004), “*Traffic Congestion and Reliability: Linking Solutions to Problems*”, pp1-5(5)

Mohammad Maghrour Zefreh and Adam Torok, (2016), “*Improving Traffic Flow Characteristics by Suppressing Shared Taxis Maneuvers*”, Research Articles of Periodica Polytechnica Transportation Engineering Vol. 44(2), pp. 69-74.

Peter KinaroMuchori, (2015), “*The Effects of Road Traffic Congestion on the Efficiency of Freight Logistics: A Survey of the Port of Mombasa*”, The International Journal of Business & Management, Vol.3(10), pp339-370

Reasat E. Noor, Mohiuddin Imran and Md. Imran Hossain, (2016), “*A Brief Study on Capacity Loss at Major Dhaka City Roads*”, International Journal of Transportation Engineering and Technology, Vol. 2(1), pp 1-7

Zhao, W. (1998), “*Delay-Based Passenger Car Equivalent for Heavy Vehicles at Signalized Intersections*”, Proceeding of ICTTS. pp. 691-700.

Olaogbebikan J.E.I.N., Akinsulire E. S. and Enosko O. (2013), “*Traffic Management Problems in Lagos: A Focus on Alaba International Market Road, Ojo, Lagos State Nigeria*”, Journal of Economics and Sustainable Development, Vol. 4(4), pp144-153