Analyses on three-wheeled vehicles in relation to congestion: A case study in Bishoftu City, Ethiopia

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A B S T R A C T

Transportation engineering aims at creating the best route between two locations within three considerations: safety, time, and cost. Drivers' behavior on roads is one of the main concerns for any traffic engineer for its effect on safety. The main objective of this topic was to investigate the impacts of Bajaj (three-wheeled vehicles) driving behavior on traffic flow and safety. The study area is located in Bishoftu City. Data were collected from a survey questionnaire, where the number distributed questionnaire was 600. The main causes of bad driving habits related to Bajaj drivers are the experience of the drivers, age of the drivers (younger drivers), low quality of license giver agencies, and road types (common road) with other vehicles. Its results were about 95% of traffic congestion caused after accidents occur at road segment rather than traffic volume occupation. This indicates that from 85% to 95% of traffic congestion was caused due to driver's wrong driving behavior habits.

INTRODUCTION

To a large extent, the safe operation of any system requiring direct human control depends on the level of behavior that the human controller provides. In the case of motor vehicle operation, the driver must sample the driving environment, select the critical aspects of the environment, determine the proper response(s), make the response(s), and evaluate the outcome(s) of the response (s) (Tasca, 2002). It is well known that traffic accident is highly important to the public health spectrum in the world. Moreover, in developing countries such as Ethiopia, the mortality rate from road traffic accidents is rather high in comparison with other countries. Not only does the majority of the people killed and seriously injured significantly affect the quality of life of the citizens but it has also a bad influence on economic and social development in the country (Tasca, 2002).

Transportation researchers have long been aware of the negative effects of driver behaviors on driving performance. Researchers have devised clever experimental designs on test tracks and simulators to gain a greater understanding of the effects of various sources of driver behavior on reaction time, lateral deviations, time-to-collision (TTC), etc., in both normal and unexpected driving environments (Abreham, 2011). Motor vehicle driving behavior is a major factor in serious traffic crashes and accounted for 582 Bajaj in number of total roadway crashes reported in Mekele (Asefa et al., 2015; Assefa, 2015). Driver behavior is even more critical at highway crossings and lane segments because truck-involved motor vehicle accidents are usually more severe compared to other motor vehicle accidents (Europian Transport Safety Council, 1996). Investigation of Bajaj vehicle driving behavior at highway crossings and lane segment is important for public safety (Sayder & Dawing, 2008). In recent years, having understood the serious effects of traffic accidents to the whole society, scientific researchers, traffic engineers and policy makers in developed country many projects and researches in the field of traffic safety. Human factor is also considered as the central element in the whole system. The final target is to organize a traffic environment, which is convenient and safe for road users (Tasca, 2002).

The research investigated the impacts of Bajaj driving behavior on traffic flow and safety. It utilized two data sources and the aspects of driving behavior at highway crossings and load segments were investigated. As well as the association between accident injury and driving behavior based on Department of Roads Authority motor vehicle crash data and the relationship between drivers' attitudes and knowledge of safe driving at highway crossings and lane segments should have to be determined (Khattak, 2013) (Eluru et al., 2012).

OBJECTIVES

The main objective of this topic is investigation on the impacts of Bajaj driving behavior on traffic flow and safety. Specific Objectives

1. To identify types of vehicle driving behavior factors for congestion at selected road segments.
2. To determine the relationship between impacts of Bajaj driving behavior and congestion on traffic safety in Bishoftu city.
3. To analyze the impacts of Bajaj drivers' driving behaviors on congestion at the selected segment.

METHODS

This study covers areas where Bajaj vehicles are widely used and which need safety improvement. From the statement of the problem point of view, we can understand that the issue is common in all parts of the country wide. As a result, the study also deals with different areas facing different problems. Therefore, to make the research feasible the study area was set on the effect of Bajaj driver's driving behavior impact on traffic flow and safety at highway crossing and road segment. A cross-sectional quantitative study was conducted in Bishoftu town, East shoa Ethiopia in June 2017. Bishoftu is located at the middle of Addis Ababa and Adama town. It is situated around

47kms, from Addis Ababa. According to the 2008 Ethiopian central statistics report, the total population of Bishoftu town is 201,408 (office, 2008).
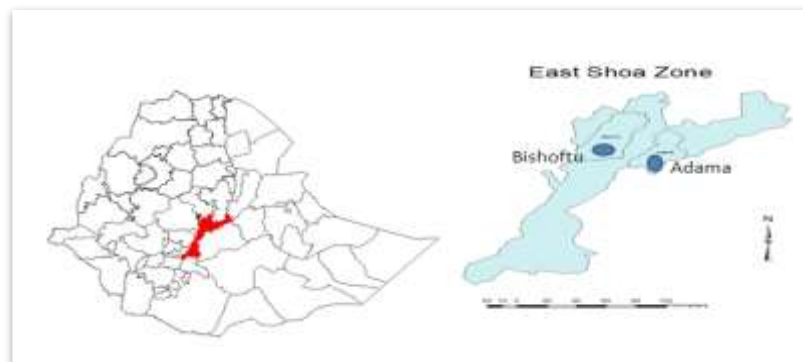

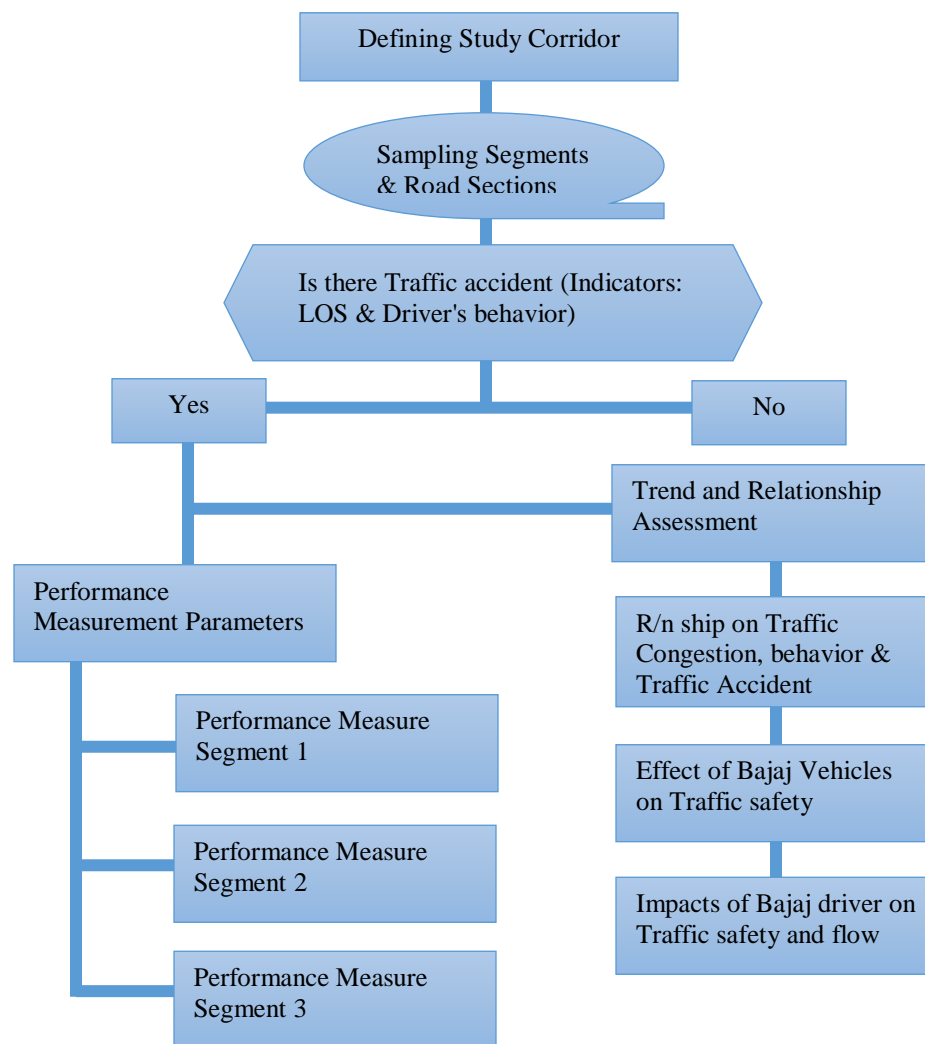Figure 1 Study area (Source:-Ethio GIS data/ArcGIS Version10.0)

Figure. 2 Framework for level of congestion, behavior & LOS analysis

System of data analysis

The traffic count was directional and hence directional traffic flow characteristics can be easily summarized and studied. As travel time data was averaged for all vehicles type and a single travel time was considered in the 15 min time interval. As discussed before, it is also necessary that the vehicle volume count should be converted to passenger's equivalent unit to conduct congestion analysis. It's used to analysis driving behavior contribution factor for congestion in traffic flow systems. Since the four specific objectives of the thesis are somewhat broader by themselves, the secondary sources Passenger Equivalent Factors with some conditional modifications were adopted to convert the traffic volume count in to PCU. The traffic volume in PCU is summarized and presented at analysis part and appendix. On this part, it seen different method of identification driving behavior impact for traffic flow and safety and way of determining driving habit. Additionally, we choose this reference because it is not done only for one country road safety condition but it is done with corporation of different countries. A structured questioner was prepared in order to gather additional information for the Bajaj driving behavior analysis. As driving behavior is a function of people's perception toward their flow and their safety purpose, it was necessary to gather information and data on how the road users (drivers', pedestrians) in this project or research corridor perceive the current traffic congestion with regard driving behavior and know can driving behavior is acceptable for them. The questioners were distributed through face to face, through interview-questioner (the data collector interview the respondent while filling the questioner) and distributing for respondent. Accordingly, about 600 questioners (for drivers, pedestrian, other concerned body) were distributed and analyzed. The researcher believes that statistically significant samples should be considered to draw conclusion out of analysis made on such questioner data. However, due to the fact that most of the basic analyses in this research are based on the quantitative data described before and the data on the questioner are a supplement for the result, the respondent size would be sufficient for the purpose of this study. Identify the relationship between traffic accident and driving behavior specially Bajaj vehicles drivers. Hence, in this study, in order to see the relationship between traffic accident and traffic congestion due to Bajaj driving behavior, different accident data were collected from secondary data.

RESULTS AND DISCUSSIONS

The analysis was made on the gathered quantitative and qualitative data to look in to the trend of the traffic flow with in the day and identify the peak period and peak hour volumes. The level of service for the identified road segment was analyzed using HCM manual and the segments were checked if they fall as congested or not congested due to driving behavior (HCM, 2000). Impact of driving behavior on traffic flow and safety analysis also made on the sections where the travel way data was collected and the results interpreted and discussed. In the driving behavior analysis, parameters for quantifying performance were analyses based on behavior approach for each section. Finally, the relationship between traffic accidents, performance, flow and safety with driving behavior was seen and a regression equation was generated.

General geometry configuration

According to general observation the main road geometric elements of Bishoftu city have two lane, 7.5m including shoulder. According to Bishoftu city Admistration report, the city have 27.19 km asphalt length and the "coble stone" 137.6 km were constructed.

Figure: 3 Geometric feature of study area segment 1 and 2 (source: during field visit photo)

Traffic flow pattern and vehicle composition analysis at segments

Directional traffic volume

A directional traffic volume analysis was conducted on a traffic volume data which is counted at 15 min interval and for 12 solid hours of a day starting from the early morning to the late afternoon. The traffic volume analysis is done for both direction and for three segments along the research corridor. The road sections or the segments considered are: 1. Hiwot building – Teachers road intersection Segment which is the city main road section (segment 1) 2. Bishoftu Bus station – Tourist intersection (Segment 2) and 3. Bishoftu roundabout – Mekonenoch club (segment 3).

Sample traffic volume data for the above three segments are summarized for all class of vehicles and reported as hourly volume in the figure 4.4 below.
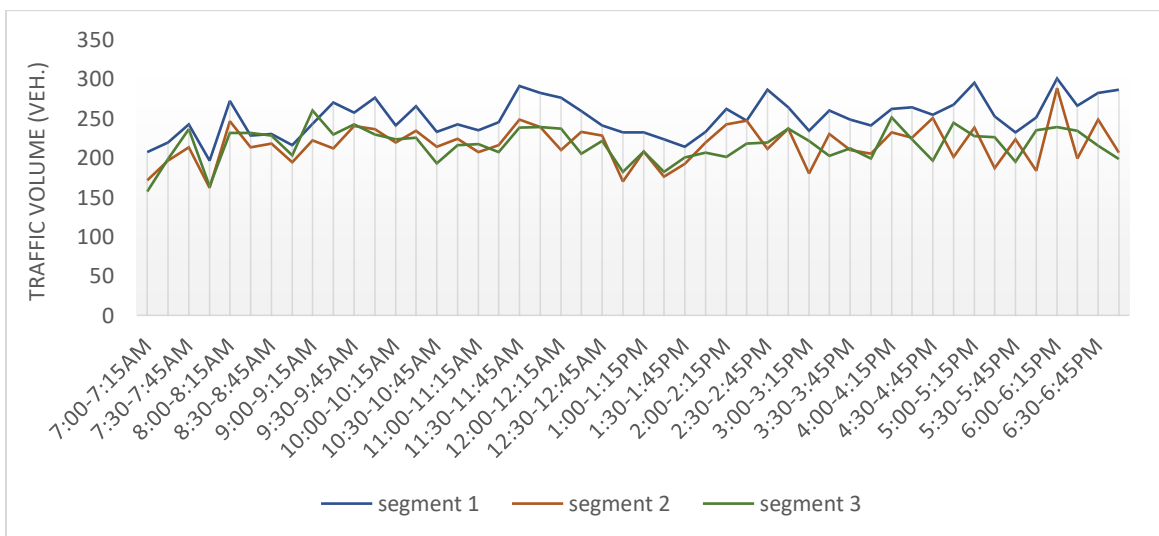

Figure 4 Volume of vehicles at the main road of Bishoftu city

In this road section, most of the vehicle share is occupied by the four vehicle classes, Bajaj, private cars, land rovers, mini bus taxi and mid buses. Those road section is a link for the traffic though Addis Ababa to Adama.
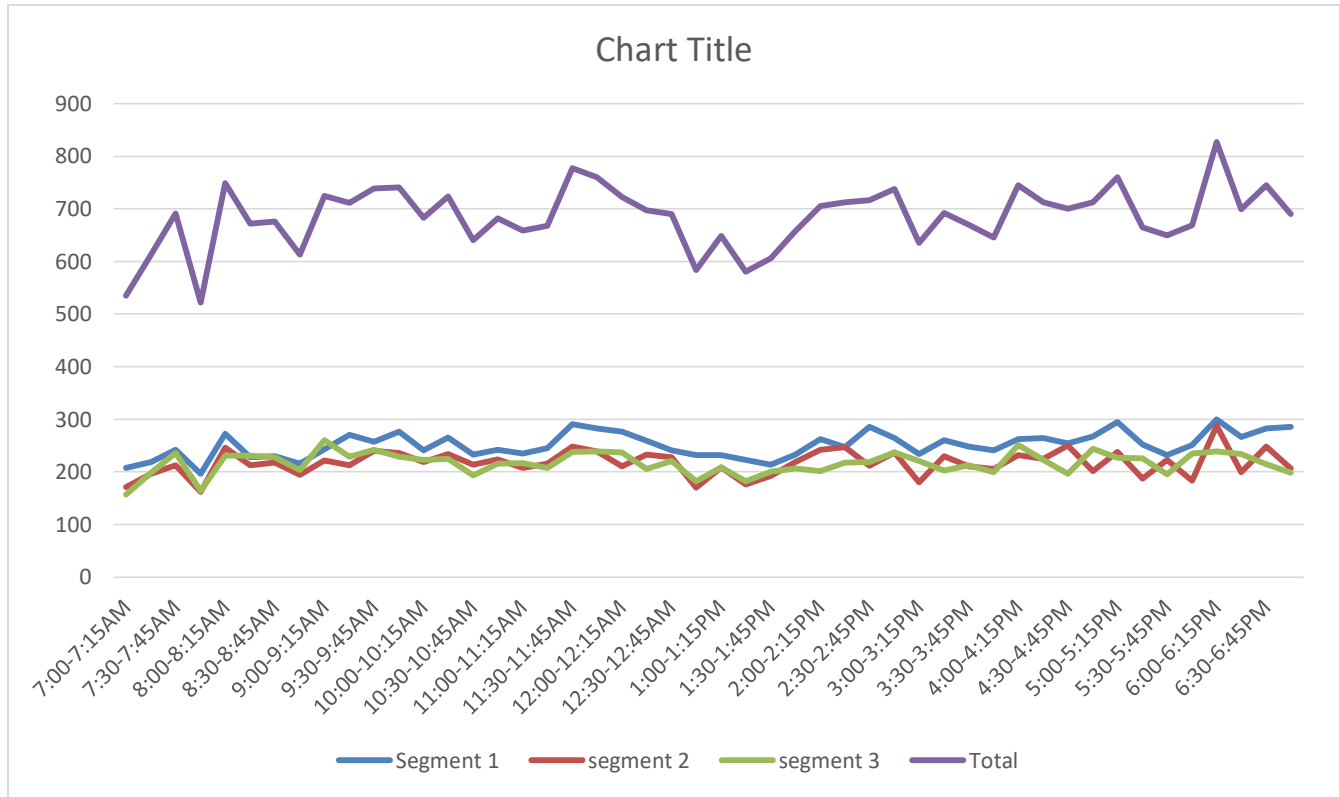

Figure 5. Total hourly volume of vehicles at the main road of Bishoftu city

Traffic congestion effect on accident

The traffic accident trend within the time of a day has been studied by different researchers. Based on the peak trends of both traffic volume and traffic accident during morning and evening time, all the previous researchers conclude that there is a relationship between traffic flow and traffic accident. However, none of the researches showed the relationship between traffic congestion parameters, traffic behavior and traffic accident. It is true that the more vehicles in the road the more likely collision would happen. However, the researcher of this paper doesn't believe that traffic flow or volume is the right parameter to be related with traffic accident. For instance at a freeway we can have the highest traffic flow or volume than other road sections. However, more of traffic accidents can happen at other section of the road.

Driver's error or behavior is highly quoted as the main (93%) cause of traffic accident in Bishoftu accounting more than 93% of the accident. The main mistakes listed under driver's error and causing about 85% of the total accident are; driving on the wrong side, failure to give way, following too close, improper overtaking, speeding, improper turning. As it can be seen together with other road and environmental factors, behavioral factors contribute a lot for the traffic accident in Bishoftu. Hence, the researcher of this paper believes that having the other road parameters constant, traffic accident would be more related with the behavioral and vehicle to vehicle headway factors than the traffic volume or flow. One of the factors that affect driver behavior is the stress, over confidence and frustration resulted from delay due to traffic congestion. A questioner result showed that out of 185 drivers interviewed 150 (81%) responded that the traffic congestion make them to stress and frustrate which make them to misbehave and commit wrong driving and most of them think Bajaj vehicles are easy to pass on a small part of road. Therefore, the link between the traffic accident, driving behavior and the traffic congestion in Bishoftu

is so significant and the researcher believes efforts made to mitigate the traffic congestion would also minimize the traffic accident but driver behavior will maximize traffic accident. Conversely, as it is clearly observed on the segments traffic accidents and road side parking are aggravating the incidence and the formation of traffic line up or queuing which in turn results in the probability of traffic congestion lowering the capacity and level of service of the infrastructure. On the other hand, one can argue congestion can reduce the high speeds on expressways and as a result of that the accident rate is reduced. But in a congested road section vehicles are closely packed and as a result of that rear - end collisions, back-up collisions as well as side collisions can occur. Most results of all this accident can be occurred due to Bajaj drivers driving behavior.

Assessing the effect of Bajaj vehicles on the congested traffic stream

An investigation into the effect of Bajaj vehicles on traffic flow during congestion is presented in this section. Several factors that are thought of as determinants of this effect were considered in this investigation. Passenger car equivalency factors applicable in HCM 2000 and HDM were utilized as an indicator of heavy vehicles" effect but regarding this researcher were did on Bajaj vehicles .

Figure: 6. Bajaj vehicle movement during congestion time (segment 3 photo)

While study results suggest some similarities between free-flow and congested traffic regimes concerning heavy vehicles" effect, some important differences exist due to the different mechanisms that govern heavy vehicles" performance in the two regimes. Also, lane-use restriction and the location of bottleneck relative to upgrade were found to have considerable influence on heavy vehicles" effect during congestion. But in case of small vehicle like Bajaj were found that on Bajaj drivers driving believing, this main cause aggressiveness on other vehicles drivers.

Segmental analysis of Level of Service (LOS)

According to the methodology described above, first, it is necessary to justify that the segments and the road sections to be analyzed are in congested state based on accepted standards and norms. Accordingly, in order to check whether the segments are congested or not, analysis was made using HCM 2000 procedures. In order to analyze the LOS using the procedures, it was made with the options right-hand driving rule and HCM 2000 metric version which represent the driving rule of Ethiopia. That is, Hiwot building – Teachers road intersection Segment section, Bishoftu Bus station – Tourist intersection and Bishoftu roundabout – Mekonenoch club Segment section.

Table 1. PCU values (source ERA manual 2011)

Less than 4 wheel Vehicle PCU value	PCU value
Pedestrian	0.15
Bicycle	0.2
Motor cycle	0.25

Bicycle with trailer	0.35
Motor cycle taxi (Bajaj)	0.4
Motor cycle with trailer	0.45
Small animal-drawn cart	0.7
Bullock cart	2.0
All based on a passenger car = 1.0	

Almost all the primary input information is gathered from the project road under analysis. These are in general the existing operational geometric feature of the highway, the current two way hourly vehicular volume, the proportions of Bajaj existence, and availability of no-passing zones as well as existing access roads/points to the main corridor.
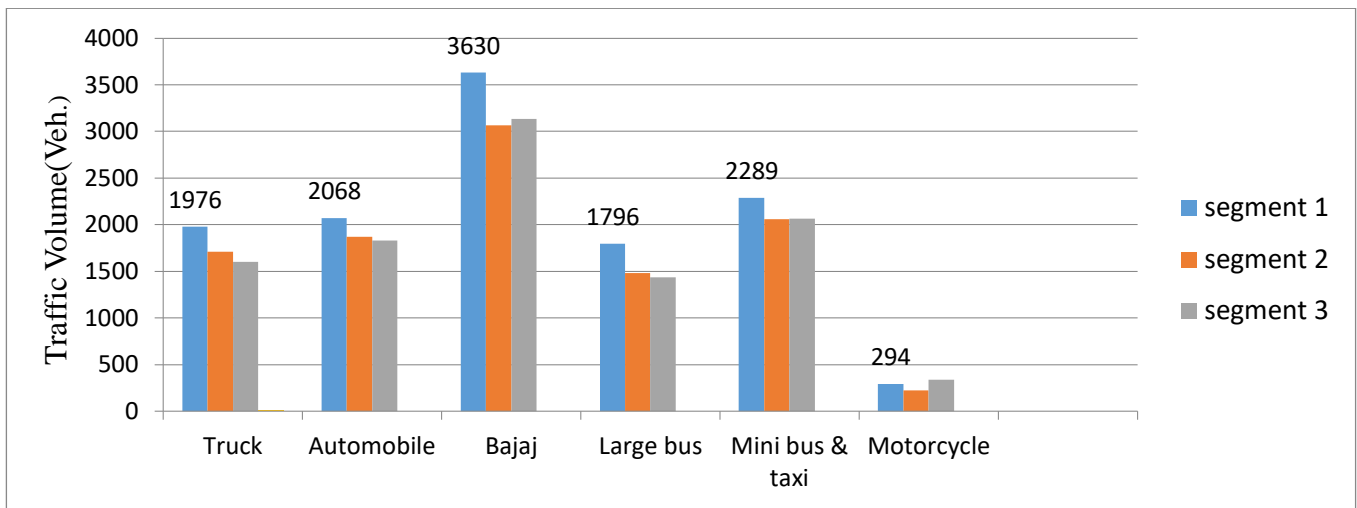

Figure. 7. Traffic volume distribution by vehicle type

Table 2. Level of service (LOS) in Bishoftu city (Data collection result)

Vehicle type	segment1 Volume(total hourly)		segment2 Volume(total hourly)		segment3 Volume(total hourly)	
	8 - 9 AM	5 - 6 PM	8 - 9 AM	5 - 6 PM	8 - 9 AM	5 - 6 PM
Trunks	621	471	615	378	618	375
Automobile	125	209	118	176	125	168
Bajaj	119	126	104	98	112	107
Bus	888	939	774	735	837	779
M/bus and Taxi	308	260	276	213	261	245
Motorcycle	7	7	6	6	7	9
Total	2067	2011	1892	1606	1960	1701
LOS	F		E		E	

Table 3. Recorded vehicles under Bishoftu transport agency (source: city transport agency)

Vehicle code	Number of vehicle
Code 1	4464
Code 2	1044
Code 3	3003
Code 4	464
Code 5	2
Special	8
Total	8985

Analysis of interview, questionnaire and field observation

Data were collected from survey questionnaire, where the number distributed questionnaire was 600. The number of returned from respondent was 552, 460 (83.7%) males and 92 (16.7%) females. The study included a sample from road segment area and two private universities (Rift valley and Admas). Statistical data of a participants in the questionnaire are shown in (Table 4.3).

Table 4. Statistical Data about the participants in the questionnaire and interviews
(source: city transport agency)

		All	Percent (%)	Male	%	Female	%
Gender	Participant	552	100	460	83.3	92	16.7
Age	<20	2	0.4	2	100	0	0
	20-30`	330	59.8	299	90.6	31	9.4
	31-40	101	18	86	85.1	15	14.9
	41-50	63	11.4	54	85.7	9	14.3
	>50	59	10.6	53	89.8	6	10.2
Vehicle ownership	Bajaj	185	33.5	180	97.3	5	2.7
	Other vehicle	140	25.4	130	92.9	10	7.1
Worker	Public Employee	80	14.5	54	67.5	26	32.5
	Private Employee	67	12.1	44	65.8	23	34.2
	College/university student	75	13.6	48	64	27	36
	Traffic police	5	0.9	3	60	2	40

Those listed above are the main problems of Bajaj and motorcycles driver driving behavior which listed according to respondent's opinion from interviews.

Figure. 4.8 Turning at any point without care around segment 2

The first part of the table (part 4.2.1) represent the participants' real application for these behaviors for example 96 (43.2%) of the participant said that Bajaj traffic accidents are very serious problem in Bishoftu city in severe traffic conditions, 148 (both agree and strongly agree) of the them said most of Bajaj driver driving habit is not comfortable/safe to pedestrian and other vehicles.

CONCLUSIONS

It was identified a types of driving behavior that affect the traffic flow and safety, according to the participants' opinion more than 90% of them decide as Bajaj vehicles impacted the traffic flow and safety, and the second objective part which represent weather the participants conducted this behavior or not, so According to the respondent's bout 95% of traffic congestion caused after accidents occurs at road segment rather than traffic volume occupation. This indicates that from 85% to 95% of traffic congestion was caused due to driver's wrong driving behavior habit.

A bad driving habit can be defined as any driving practice that is inherently unsafe, illegal or not in line with international best practice that causes:

1. Experience of the drivers.
2. Age of driver (younger drivers): a younger driver those got a license (age 20-30) have revealed that up to 75% believe they are "above average" drivers.
3. Low quality of license giver agencies.
4. Road types (common road) with other vehicles.

The impacts of Bajaj driving behaviors for congestion and the main causes of congestion that impacts related to Bajaj driving behavior are, close following and tailgating, lane violations and zigzag driving or passing, being unfocused and distraction, lane change without attention, yield violations for other vehicles and pedestrians, sudden turning and stopping, Speeding over the speed limit and violation of traffic signs and traffic rule

RECOMMENDATIONS

The following recommendation are needed to improve traffic flow and traffic safety in Bishoftu: It recommended to improve Bajaj drivers driving behavior impact through the following:

1. Education and awareness for drivers and pedestrians: education and awareness giving for drivers must be attended at school level, especially at license giver agencies. The agency has the responsibilities to produce responsible driver before licensed.
2. Separate the common roads of Bajaj and other vehicles: Bishoftu city have a lot of optional road to manage traffic flow and accident, so it is better to use different road for vehicles and Bajaj vehicles.
3. To encourage drivers to drive defensively and to obey traffic rules and regulations in all circumstances.
4. To increase the number of traffic police patrols on the most hazardous and dangerous streets.

REFERENCES

Abreham H.A.G. (2011). Risky driving behavior for road traffic accident amang drivers. *BMC research note*.

Ajzen, l. & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. *Englewwood-Cliffs*.

Asefa, NG,et al., (2015). *Roadway Crashes Report.* Mekele.

Assefa, NG (2015). Road crash report. 55-65.

commission, B. t. (2009). *Report on road traffic accident.* Bishoftu.

Durth, W. (1994). Risk Analysis in road Engineering. *Forschung StraBenbau*, 89-94.

E,L. (2007). Road traffic injury is an escalating burden in Africa and deserves proportionate research efferts. *PLO medecine, 4*, 0967-0971.

Eluru, N., Bagheri, M., Miranda-Moreno, L.F., & Fu, L. (2012). A latent class modeling approach for identifying vehicle driver injury severity factors at Highway-railway crossing. *Accid.Anal*, 119-127.

Europian Transport Safety Council (1996). Seat belts and child restraints: increasing use and optimising Performance.

Fan, W.D. & Haile, E.W. (2014). Analysis of severity of Crashes at Highway-Rail Grade Crossings:Multinominal logit modeling. *Transportation Research board*, 14-58.

Finch J, Kompfne P, Lockwood R, & Maycock G. (1994). Speed limits and accident Transportation research Laboratory. 50-62.

FPC (2007). *Police commission report.* Addis Ababa: Federal repuplic of Ethiopia.

G, G. (2004). Alcohol and road traffic injuries in south Asia:challenges for preventation. 14, 113-118.

HCM. (2000). *Highway capacity manual.*

Hermers, G. & Aberg, L. (1978). Driver behavior intersection are related to priority rules and road design.An exploratory study. In E. e. al.

Hsu, T. & Nguyen, X.D. (2003). A comparative study on Motorcycle traffic development of Taiwan. *Eastern Asia Society for transportation*, 45-60.

Hu, S.R., Chin-Shang, L., & Chi-Kang, L. (2010). Investigation of key factor for Accident Severity at Railroad grade crossings by using logit model. *safety science*, (pp. 186-194).

Huyen, L.t. (2009). Risk Analysis, Driver Behavior and traffic safety at intersection in motorcycle-dominated traffic flow.

I, C. (2001). Impact of rehabilitation course attendance on convict drink drivers.

Jonah, M.B. (1997). Sensation Seeking and Risky Driving:a review and synthesis of literature Accident Analysis and prevention. 75-78.

Khattak, A. (2013). Severity of Pedestrian crashes at Highway-rail grade crossings. *Transportation research*, 13-45.

Larsen, L. & Kines, P. (2002). Multidiciplinary in-depth investigations of head-on and left-turn road collisions, accident analysis and prediction.

Mercier, C.R., Mack, C., Shelley, G.H., Adkins, & Mercier, J.M. (1999). age and gender as predictors of Injury severity broadside and angle vehicular collisions. *Department of Transportation*, 50-62.

Minderhoud, B. (2007). Extended time-to-collision measures for road traffic accident. 33.

office, B. c. (2008). *Bishoftu city administration office year report.*

P, C. (2002). Association of driver air bags with driver fatality:a matched cohort study. *BMJ*, 119-122.

Peter, T. Martin. (2003). Evaluation of Advance Warning Signal on High speed signalized intersection. 65.

Russo,B. & Savolainen, P.T. (2013). An examination of factor Affecting the Frequency and Severity of Crashes at Rail-grade Crossing. *Transportation Research board*, 13-16.

Saccomanno, F.F., Liping, F., & Miranda-Moreno, L.F. (2004). Risk based model for Identifying High-rail grade Crossing black spots. *Transportation research record*, 127-135.

Shinar, D., R.C. (2004). Aggressive driving: an observational study of drivers, in accident anaysis and preventation. *36*(accident analysis), 429-437.

Tasca, L. (2002). A Review of the literature on aggressive driving research, Ontario Ministry of Transportation. 42-47.

Tasca, L. (2002). Research on Aggressive driving behavior. *Ontario Ministry of transportation*, 042-047.

Yilma, B., Million, T., & Luce, T. (2010). motor vehicle accident and fatality surveillance Addis Ababa 2000-2009.