Prediction of the Occurrence of Crashes along the Dar es Salaam Bus Rapid Transit (BRT) Corridor, Tanzania

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Abstract - *In fact, poor infrastructure is the main reason for the road accidents that occur every day. In most of the developing countries especially Africa, Tanzania being one of the African countries is no exception, the issue of public transport is a big challenge. There are number of factors associated which are the main reasons for the occurrences of crashes within a particular road corridor however the extent to which each factor is related to crash occurrences varies. This Paper is focusing on predicting the occurrences of crashes using significant factors that lead to crash occurrences within the Bus Rapid Transit (BRT) Phase 1 corridor. Through the use of negative binomial regression (NB) as a predictive model, the research discovered that the crashes in the BRT corridor will be lowered to 39.5% during the period of operations of BRT buses. As this is good sign to the public traffic safety, the research recommend the government to speed up to continue with construction of other phases in order to facilitate proper and safe public transport to the people particularly in Dar es Salaam.*

***Key Words*: Prediction, Occurrence, Crashes, BRT, Dar es Salaam.**

1. INTRODUCTION

Considerable research has been carried out in recent years to establish relationships between crashes and traffic flow, geometric infrastructure characteristics, land use and environmental factors ([1]). The statistical approaches have generally included Poisson and Negative regression models, whilst negative multinomial regression model has been used to a lesser extent. A study by [2], states that the use of geometrical information of the road corridor and environment factors to be the key information to predict the occurrence of crashes. In fact the study from various researchers has shown that the results differ from one corridor to another corridor given that the roadway geometry or land use or environment information differs between the corridors. The model developed in this paper for Tanzanian (Dar es Salaam BRT corridor) roadway geometry appear to be useful for many applications such as detection of critical factors, and prediction of crashes occurrences due to improvement in the road corridor. The findings from previous researcher described both of the listed models above, and suggested other researcher to use the prediction model depending on the type of data. Since crash data are count variables, which according to the study by [3] is best represented by a Poisson distribution. However, further studies from other researchers found that crash data are also over-dispersed meaning that the variance is much larger than the mean hence are better represented by a negative binomial distribution, which, unlike Poisson distribution, allows the variance to differ from the mean ([4], [5]). Furthermore the study by [3], [4] found negative binomial (NB) regression as a best method for modeling crash frequencies in most cases.

2. LITERATURE REVIEW

2.1 Commuter Bus Crashes in Dar es Salaam Before Construction of BRT System

Chronologically, [6] in their findings using traffic police accident data states that average of 4191 commuter bus crashes occurred each year from 1993 to 1997. Also the study revealed that for 1997 and 1998 an average 24% of the total vehicles involved in accidents were commuter buses while 51% were private cars, 16% were pickups, 0.3% were long distance buses and other vehicle types accounted for 8.7%. The study described that within the public transport sector, long distance buses represented 1.3% of vehicles involved in accidents whereas commuter buses (daladala) represented 98.3% of vehicles involved in accidents. Commuter buses are among of the major contributor to the traffic crashes in Dar es Salaam, the pressure of daladala drivers to achieve daily targets may well contribute to high involvement in crashes ([6]). [7], states that accident and safety are among of the challenges facing urban transport in Dar es Salaam. The recent study by [8] utilizing police crash records indicated that about 12.77% of all crashes involves commuter buses by themselves and 13.5% crashes occur between commuter bases with other vehicles while another 3.12% crashes occur between commuter buses with motorcycles.

The study by [9] stated by reviewing on operational feature in which vehicle, route coverage and service frequency, the use of Intelligent Transportation System (ITS) technology as applied to BRT, fare collection method and operational speed. The findings states that using buses with exclusive right of way for bus only experienced 40% fewer accidents than mixed traffic operations. Furthermore the study [10], Bogota BRT systems which was based on historical data discovers a larger reduction about 93% of death from traffic accident among the road users. The same result was mentioned by another researcher [11], in his study about exploring bus lane safety impacts using traffic micro-simulation, who add that as compared to a mixed traffic configuration the provision of bus lanes, regardless whether it was created though space reallocation or space creation act to lower the number of conflicts at intersection approaches and bus stop locations. On other hand, [12] state that center lane configurations, left turn prohibitions, and signalized midblock pedestrian crossings with traffic islands consequentially improve safety on corridors where BRT operates. In Istanbul, where minibuses and regular bus routes were removed and the deployment of new buses in dedicated lanes lead into 64 percent reduction in bus accidents in one year ([13]).

Furthermore, the overall safety impact of implementing a bus system on a corridor varies depending on the characteristics of the system and the existing conditions on the street ([12]). Further research on the impact of implementing BRT systems on traffic safety has generally proven to have a positive. However other types of corridors, such as Busways or bus priority lanes, have not always had the same positive impact ([12]). A BRT usually involves eliminating several mixed traffic lanes on a street, separating bus traffic from other modes, or expanding a median (in the case of center-lane BRTs) which reduces the length of pedestrian crossings. In general, the BRT operations are better organized, commonly replacing a variety of services with a single operating agency with common standards for driver training, vehicle maintenance, etc. For instance Macrobus in Guadalajara contributed to significant reductions in crashes and fatalities on their respective in crashes and fatalities by 46% and 60% respectively on the corridors. However not all bus systems had the same positive impact on safety. The Cristiano Machado Busway, in Belo Horizonte (Brazil) remains the street with the highest crash frequencies citywide, despite the presence of a central Busway. In Delhi, after the implementation of the BRTS system, traffic fatalities initially increased on the corridor, and crashes between buses and pedestrians a more positive impact than others ([12], [14])

3. METHODOLOGY

In this study; non probability method of sampling was used ([15]). With regard to the sample being selected, a purposive sampling which is the types of non probability was employed due to the fact that the BRT phase 1 which was selected is a typical phase having operating BRT system in Tanzania. Also the reason for selecting commuter buses is that the crashes between daladala to daladala are obvious suspected to cause larger number of fatalities and injuries which place daladala to have typical crash among other vehicles. Also the availability of data was one of the reasons guided the researcher to use crash data of four years from 2008 to 2011 This study fall under case study method as a research design strategy in which Dar es Salaam BRT phase one corridor is taken as a case study area ([15]). On other side this study used commuter bus crashes before construction from 2008 to 2011, traffic count from Tanzania National Roads Agency (TANROADS), roadway geometric data and land use information whereas the data were collected by observations and documentary review. Under observations, The roadway geometry data were lane width, informal bus stops, formal bus stops, size of median, service road, zebra, Intersection either signalized or unsignalized, number of driveways, land terrain, land use information for each particular segment link and weather condition. Furthermore safety and security system of BRT buses, general condition of BRT terminals/stations, and cross sections of BRT corridor were obtained through observations. On other hands, documentary review was based on crash data from police station (Ilala and Kinondoni), traffic count from TANROADS and BRT route schedules and operations from Dar es Salaam Rapid Transit (DART) agency.

Inferential statistics methods was used to determine the factors associated with the commuter bus crashes occurrences under which the researcher selected the crash prediction model which is relevant to the type of data. Crash data are count variables, which according to the study by [3] is best represented by a Poisson distribution. However, further studies from other researchers found that crash data are also over-dispersed meaning that the variance is much larger than the mean hence are better represented by a negative binomial distribution, which, unlike Poisson distribution, allows the variance to differ from the mean ([4], [5]). Furthermore the study by [3], [4] found negative binomial (NB) regression as a best method for modeling crash frequencies in most cases.

4. RESULTS, ANALYSIS, AND DISCUSSION

4.1 Data Processing

This involves manipulation of items of data to produce meaningful information. Some of the basic processes included during this study are; ensuring that supplied data is correct and relevant, arranging items in some sequence and/or in different sets, reducing detail data to its main points, combining multiple pieces of data, separate data into various categories and lastly data coding whereas those data in words were transformed into numerical so as to access the use of Stata12. Cording of data require thinking and reasoning toward a particular statement. For instant it is logic to say sloped terrain is more dangerous to crash occurrences than flat terrain, therefore flat terrain need to be represented by zero (0) while sloped terrain need to be represented by one (1). In this study, those processes listed above was done by using Microsoft excel. Table 1 below shows the description of coding for various variables and the way was represented with numerical number.

Table 1: Description of coding for variables

Variable	Mode of coding with regard to the occurrence of crashes
Terrain	Flat=0, and Sloped=1
Land use	Mixed=0, Residential=1 and Commercial=2

Weather condition	No rain=0 and Rain=1
Bridges	Yes= 0 and No= 1
Service road	Yes=0 and No =1
Median	Yes = 0 and No =1
Walkway	Yes=0 and No =1
Pedestrian density	Low=0, Median=1 and High=2

Source: Authors, (2016).

4.2 Modeling Commuter Bus Crashes Occurrence for Dar es Salaam BRT Corridor

This part presents how the variables related to occurrences of commuter bus crashes correlate with each other, modeling procedures, and lastly summarize the reason for selecting one mode over another. The model variable definitions and statistical summary are presented in Table 2 below.

Table 2: Variable Definitions & Data Summary (number of segment link= 39)

Variables	Symbol	Source	Min	Max	Mean	Std. dev
Segment length	sgmlength	Google earth	0.4	0.6	0.536	0.053
Number of lanes	nooflanes	observation	2	6	5.538	1.166
BRT lane width	BRT lane	observation	3.6	3.6	3.6	0
Lane width	Lanewidth	observation	3	3	3	0
Presence of median	medianyesno	observation	0	1	0.359	0.486
Raised median	raisedmedian	observation	0	0.8	0.218	0.199
Number of informal bus stop	inforbusstop	observation	0	2	0.282	0.56
Number of formal bus stop	formbusstop	observation	0	2	0.615	0.544
Number of driveways	nodrivewways	observation	0	11	3.333	2.527
Number of intersection	nointersectns	observation	0	7	1.641	1.799
Signalized	signalized	observation	0	2	0.641	0.707
Un signalized	unsignalized	observation	0	5	1.128	1.49
Threeleg intersection	Threeleg	observation	0	5	1.026	1.224
Fourleg intersection	fourleg	observation	0	5	0.538	1.189
Zebra crossing	zebra	observation	0	3	1.462	1.022
Presence of sidewalk	walkwayesno	observation	0	1	0.795	0.409
Width of walkway	Walkway (m)	observation	0	2.5	1.859	1.013
service road	servroadyesno	observation	0	1	0.899	0.307
Presence of pedestrian bridges	Bridges	observation	0	1	0.897	0.307
Number of daladala per day	noofdaladala	Tanroads	416	1217	680.95	257.23
Pedestrian density	peddensity	observation	0	2	1.436	0.788
Total number of crashes	total crashes	Police station	3	45	17.59	11.67
ADT	ADT	Tanroads	5300	26401	19872.5	7351.27
land use	land use	observation	0	2	1.128	0.864
Terrain	terrain	observation	0	1	0.256	0.442
Weather condition	weather	observation	0	1	0.282	0.456

Source: Authors, (2016).

Table 2 above shows various variables used in analysis as collected by the researcher. The mean indicates the average of items per 39 segment links under considerations. Moreover the standard deviation (std. dev.) indicates the amount of variation or dispersion of a set of data.

4.3 Modeling Methodology

Crash data are count variables, which according to the study by [3] is best represented by a Poisson distribution. However, further studies from other researchers found that crash data are also over-dispersed meaning that the variance is much larger than the mean hence are better represented by a negative binomial distribution, which, unlike Poisson distribution, allows the variance to differ from the mean ([4], [5]). Furthermore the study by [3], [4] found negative binomial (NB) regression as a best method for modeling crash frequencies in most cases.

Due to the reason stated above, the researcher preferred a use of negative binomial to develop a crash prediction model. This regression specifically accounts for extra Poisson variation of collisions, and is widely used in many studies for both micro and macro-level crash prediction model. The formulations for NB regression are presented as follows:

$$Y_i/E_i \sim \mathit{poisson}(E_i) \quad \ldots 1$$

$$E_i=\mu_i \quad \ldots 2$$

$$\mathrm{In}(\mu_i)=\beta_0+\beta_1X_{i1}+\beta_2X_{i2}+\beta_3X_{i3}+\beta_4X_{i4}+\ldots+\beta_mX_{im} \quad \ldots 3$$

$$E_i \sim \mathit{Gamma}(\lambda_i, K_i) \quad \ldots 4$$

Where

Yi = number of crashes at a location *i,*

Ei, ƛi, Ķi= the distribution parameters,

Xij = independent variables.

So in Equation 1, the observed number of crashes at location *i*, *Yi*, follow a Poisson probability distribution with the parameter of expected number of collisions, *Ei*. And the parameter *Ei*, seen as another random variable, is presented in equation 3 and assumed to follow a Gamma distribution

4.4 Variable Selection

To develop each crashes prediction model, the first step involves selecting significant variables from group of independent variables. This procedure of variable selection is said to be a forward stepwise procedure, first, all independent variables were tested to obtain correlation matrix which is presented in Table 3 below. The correlation matrix enables to know which variables are much correlated and hence avoid including such variable in the model at once.

Table 3: Correlation matrix for variables

	totalc~s	SGTlen~m	Noofla~s	median~o	raised~M	inforb~p	formbu~s	nodriv~s	Nointe~s	signal~d	Unsign~d	fourleg
totalcrashes	1											
SGTlengthkm	-0.2996	1										
Nooflanes	-0.3507	0.2777	1									
medianyesno	0.2587	-0.5184	-0.5357	1								
raisedmedi~M	-0.0887	0.4163	0.4459	-0.8324	1							
inforbusstop	0.0262	0.0046	0.2047	0.1017	-0.1415	1						
formbusstops	-0.0048	-0.2411	0.2107	-0.1609	0.09	0.2795	1					
nodriveways	0.1449	-0.2116	-0.5179	0.5429	-0.4424	-0.0124	-0.1532	1				
Nointersec~s	0.3425	-0.3754	-0.5827	0.5727	-0.431	0.0248	-0.0103	0.8432	1			
signalised	0.2912	0.0018	-0.0147	-0.0747	0.216	0.0631	0.1107	0.2456	0.4135	1		
Unsignalised	0.215	-0.3295	-0.6616	0.6616	-0.5863	-0.0129	-0.1	0.834	0.9209	0.0949	1	
fourleg	0.4185	-0.1281	-0.5373	0.3855	-0.2874	0.003	-0.2412	0.438	0.5604	0.2988	0.5098	1
zebra	0.2612	0.0755	-0.214	0.1345	-0.0938	0.2265	0.0911	0.3464	0.3501	0.2355	0.323	0.2016
walkwayesno	0.0591	-0.1382	0.4582	-0.017	0.0789	0.2594	0.1092	-0.0085	0.0403	0.2848	-0.0421	-0.1457
walkwayM	0.0328	-0.0508	0.545	-0.1885	0.2224	0.3275	0.2096	-0.2382	-0.1585	0.2584	-0.258	-0.1976
serviceroa~o	0.1274	-0.0105	-0.1355	0.253	-0.1416	0.1726	0.0727	0.1807	0.3124	0.1895	0.2593	0.1551
Bridges	-0.1441	0.0711	-0.1355	0.0768	-0.2278	-0.4394	-0.2423	0.1129	0.0268	-0.174	0.1444	0.0831
noofdaladala	-0.0025	0.1356	0.1099	-0.2744	0.2301	-0.2305	0.0318	-0.1973	-0.3266	-0.1382	-0.3222	-0.041
peddensity	0.2117	-0.1656	-0.1762	-0.0758	0.1506	0.0122	-0.0284	0.3084	0.2804	0.2412	0.1977	0.1924
ADT	-0.1897	0.4982	0.4091	-0.8679	0.7354	-0.0862	0.03	-0.6711	-0.6932	-0.0329	-0.7491	-0.2022
landuse	-0.0677	0.157	0.217	-0.2379	0.3085	0.2499	0.0517	0.0281	-0.0543	0.1205	-0.0744	-0.1459
terain	-0.1269	0.0465	0.2354	-0.1946	0.0661	-0.0872	-0.0168	-0.408	-0.4104	-0.2029	-0.3706	-0.1694
weather	0.0668	-0.1043	0.0533	0.2437	-0.261	0.1957	0.2369	-0.1751	-0.0337	0.2409	-0.0934	0.1494

	zebra	walkwa~o	walkwayM	servic~o	Bridges	number~a	pedden~y	ADT	landuse	terain	weathe~n
zebra	1										
walkwayesno	0.0436	1									
walkwayM	0.0518	0.9447	1								
serviceroa~o	0.3222	0.2469	0.2059	1							
Bridges	0.1547	-0.1717	-0.2168	-0.1143	1						
noofdaladala	-0.1964	-0.528	-0.4352	-0.3968	-0.0164	1					
peddensity	0.2665	0.2847	0.2605	-0.0279	-0.2452	-0.3059	1				
ADT	-0.238	-0.1486	0.0916	-0.2782	-0.0997	0.3914	-0.0166	1			
landuse	0.0206	0.2998	0.2919	-0.1474	-0.2465	0.0294	-0.0069	0.1509	1		
terain	-0.3851	0.0075	0.0828	-0.3821	0.005	0.4495	-0.4046	0.2901	0.256	1	
weather	-0.1173	0.1773	0.2594	0.2119	0.0241	0.0109	-0.278	-0.0367	-0.1611	0.1539	1

Source: Authors, (2016).

The determination to keep a variable in the model was based on whether the variable meet all of the following criteria: first, the logic (i.e. +/-) of the estimated parameter was intuitively associated with collisions; second, the t-statistic for each parameter was significant at the 90% confidence level; and lastly the added variable should make a significant drop in scaled deviance (SD) at 90% confidence level ([16]). The second step involved was to test the model by selecting all independent variables given that the variable are not much correlated as presented in Table 3 above. On other words, correlation matrix is used to investigate the dependence between multiple variables at the same time. Moreover, if the correlation coefficient is greater than 0.8, then it is generally described as strong, whereas a correlation coefficient less than 0.5 is generally described as week. The result after this step was summarized in the Table 4.

Table 4: Initial model of negative binomial regression

Negative binomial regression				Number of obs =	39
				LR chi2(22) =	52.44
Dispersion = mean				Prob> chi2 =	0.0003
Log likelihood = -118.78595				Pseudo R2 =	0.1808
totalcrashes	Coef.	Std. Err.	Z	P>|z|	[90% Conf. Interval]
Nooflanes	-.7306115	.1268305	-5.76	0.000	-.9791946 - .4820283
medianyesno	-.3434303	.4662065	-0.74	0.461	-1.257178 .5703175
raisedmedianM	-.9995744	.6797759	-1.47	0.141	-2.331911 .3327619
inforbusstop	-.0212637	.1785988	-0.12	0.905	-.3713108 .3287835
formbusstops	.0386982	.1734974	0.22	0.823	-.3013504 .3787468
nodriveways	.0386982	.0680491	-1.97	0.049	-.2672749 - .0005274
Nointersectns	.8138379	.2381133	3.42	0.001	.3471445 1.280531
signalised	-.8862852	.2586286	-3.43	0.001	-1.393188 - .3793824
Unsignalised	-1.31447	.2767221	-4.75	0.000	-1.856835 - .7721042
fourleg	.4049927	.2018556	2.01	0.045	.0093629 .8006225
zebra	.3686603	.158471	2.33	0.020	.0580629 .6792577
walkwayesno	.4130195	.1010052	4.09	0.000	.215053 .6109861
walkwayM	5.31011	1.186053	4.48	0.000	2.985489 7.634731
servroadyesno	-1.237424	.4602212	-2.69	0.007	-2.139441 - .3354066
Bridges	-1.035309	.3278965	-3.16	0.002	-1.677975 - .3926437
noofdaladala	-.6418215	.3215417	-2.00	0.046	-1.272032 - .0116113
peddensity	.0017845	.0004265	4.18	0.000	.0009485 .0026205
ADT	-.5056532	.1622744	-3.12	0.002	-.8237051 - .1876013
landuse	.0000669	.0000348	1.92	0.055	-1.38e-06 .0001352
terrain	-.098203	.099627	-0.99	0.324	-.2934683 .0970623
weather	-.7527162	.2723217	-2.76	0.006	-1.286457 - .2189755
_cons	5.224622	1.065471	4.90	0.000	3.136337 7.312906
/lnalpha	-2.875953	.480357			-3.817435 - 1.93447
alpha	.0563624	.0270741			.0219841 .1445008

Source: Authors, (2016).

Table 4 above has indicated the influence of each variable over the occurrence of commuter bus crashes. As indicated that median width as one of the independent variables has no effect on the crash prediction mode because there was no variation in median width. The researcher set a significant level of 10% to capture only factors which are significant at 10% significant level meaning that other factors were removed. The significant level has the meaning to the model such that the P>|z| values should be less than 1 otherwise the factor has to be removed. Therefore after setting the significant level to 10% those variables with P values above 0.1 were removed to the model and the result is shown in the Table 5 below. The variables removed at this stage involve formbusstops, inforbusstop, medianyesno, and weather where both of these factors where having the value of p >= 0.1000.

Table 5: Second model of negative binomial regression

	Negative binomial regression = 39			Number of observation	
				LR chi2(13) =	37.75
	Dispersion = mean			Prob>chi2 =	0.0003
	Log likelihood = -126.12968			Pseudo R2 =	0.1302
total crashes	Coef.	Std. Err.	Z	P>|z|	[95% Conf. Interval]
Nooflanes	-.652474	.1253782	-5.20	0.000	-.8982108 -.4067371
weathercondition	-.3633096	.2102653	-1.73	0.084	-.775422 .0488028
raisedmedianM	-1.014153	.5415407	-1.87	0.061	-2.075553 .0472474
peddensity	-.3246692	.140982	-2.30	0.021	-.6009889 -.0483495
terrain	-.8648002	.2805972	-3.08	0.002	-1.414761 -.3148399
numdriveways	-.1864874	.0612895	-3.04	0.002	-.3066126 -.0663622
Numintersectns	.9485011	.2249222	4.22	0.000	.5076616 1.38934
signalised	-.5571821	.234317	-2.38	0.017	-1.016435 -.0979293
Unsignalised	-1.003305	.2639518	-3.80	0.000	-1.520641 -.485969
numberofdaladala	.0019506	.0004627	4.22	0.000	.0010438 .0028574
zebra	.1633592	.0775696	2.11	0.035	.0113255 .3153928
walkwayesno	2.08976	.4079239	5.12	0.000	1.290244 2.889276
serviceroadyesno	-.6670168	.3264122	-2.04	0.041	3.6947 6.858135
_cons	5.276417	.8070133	6.54	0.000	3.6947 6.858135
/alpha	-2.241899	.3687217			-2.96458 -1.519217
alpha	.1062566	.0391791			.0515821 .2188832

Likelihood-ratio test of alpha=0: chibar2 (01) = 13.13 Prob>=chibar2 = 0.000. **Source:** Authors, (2016).

Table 5 above shows several variables having significant influence on the crash prediction mode with their coefficients. However some of these variables were removed because of the consideration explained already under variable selection. For instant, the negative sign for unsignalized intersection has the meaning that the presence of unsignalized intersection reduces the occurrence of commuter bus crashes which in real sense is not true and therefore the variable is disqualified to have influence on the occurrences of commuter bus crashes. Also the positive sign for zebra indicate that the presence of zebra crossing tends to increase the chance of crash occurrences however this does not make sense and need to be removed from the model. Due to this reasons, the researcher has performed father analysis to remove those variables contradicting the crash prediction mode. Table 6 below presents the results from this stage.

Table 6: Final model of negative binomial regression

Negative binomial regression			Number of obs = 39		Marginal effects after nbreg			
			LR chi2 (6) = 19.58					
Dispersion = mean			Prob> chi2 = 0.0033					
Log likelihood = -135.2144			Pseudo R2 = 0.0675					
Number of crashes	Coef.	Std. Err	Z	P>|z|	dy/dx	Std. Err	Z	P>|z|
Number of lanes	-0.369	0.121	-3.05	0.002	-5.946	1.981	-3.00	0.003
Absence of walkway	1.179	0.355	3.32	0.001	14.216	3.392	4.19	0.000
Flat terrain	-0.439	0.252	-1.75	0.081	0.021	0.008	2.78	0.005
Number of intersections	0.206	0.101	2.04	0.041	3.325	1.641	2.03	0.043
Number commuter buses	0.001	0.0005	2.82	0.005	-2.933	1.091	-2.69	0.007
Number of driveways	-0.182	0.067	-2.73	0.006	-6.413	3.362	-1.91	0.056
_cons	3.362	0.627	5.37	0.000	dy/dx is for discrete change of dummy variable from 0 to 1			
/lnalpha	-1.591	0.297						

alpha	0.204	0.061		

Likelihood-ratio test of alpha=0: chibar2 (01) = 69.10 Prob>=chibar2 = 0.000. **Source:** Authors, (2016).

4.5 Results and discussion

This part focus on the results obtained from the analysis above. The discussions under this part are based on the objective of this study. First, six variables as obtained to be the factors associated with the occurrences of crashes. Those factors as presented in the final regression model were analyzed; its contribution to crash occurrences as provided in Table 6 above was applied to find the percentage that each variable can contribute on the occurrences of crashes. Secondly, the discussions are also about the modifications on roadway geometry and challenges to the road users.
Basing on the preferred final crash prediction model,

Let X_1= Nooflanes,
X_2= walkwayesno,
X_3= terrain,
X_4 = Numintersectns,
X_5= numberofdaladala,
X_6= numdriveways

In (total crashes) = 3.36192 - 0.3687877*Nooflanes + 1.178782*walkwayesno - 0.4391193*terrain+0.2062115*Numintersectns +0.0013283*numberofdaladala - 0.1819297* numdriveways

The negative binomial regression coefficients of X_1, X_3 and X_6 present that number of lanes, terrain, and number of driveways in one way or another reduce the chance of commuter bus crashes, on the other side, the positive binomial regression coefficients of X_2, X_4 and X_5 present that walkway, number of intersection and number of daladala increase the chance of commuter bus crashes. Table 6 above describes six variables having significant influence on the crash prediction model. Number of lanes, walkway, terrain, Number of intersection, number of daladala (commuter buses) and lastly number of driveways are the list of variables that fit the model and are explained under this section. Furthermore, Table 6 shows the marginal effect of the predicted number of event after negative binomial regression. The relationship of each variable if other factors are kept constant to the occurrence of commuter bus crashes are presented as derivatives dy/dx as follows;

dy/d(Nooflanes) = -5.946056……………………………..5
dy/d(walkwayesno) =14.21639……………………………6
dy/d(numberofdaladala)=.0214166………………………7
dy/d(Numintersectns) = 3.324799………………………..8
dy/d(numdriveways) = -2.933298………………………9
dy/d(terrain) = -6.413048…………………………………10

a) Number of lanes, this has the coefficient -0.369, which means that having number of lanes increased tends to increase the chance of crash occurrence and the vice versa is true. Different studies have described the correlation between number of lanes and crash occurrences, since number of lanes goes proportional to the road width, the study by [12] using negative binomial regression model have discovered road width as one of the key issue particularly due to its influence at intersection, and cross walk distance. According to the finding of this research using negative binomial regression 10% level of significant in Table 6 predict that if other factors are kept constant the increase in number of lanes along the BRT corridor will increase crash occurrences by 12%(see equation 5)

b) Walkway, this has the coefficient 1.179, with positive sign meaning that absence of walkway tends to increase chance of crash occurrences and the vice versa is true. This argument obvious make sense because in congested area if there is no walkway may lead pedestrian to interfere traffic lanes and then increase the chance of crash occurrence. The observations of traffic safety inspections found the presence of walkway in the whole corridor by almost 90%. Therefore this study predicted that the chance of crash occurrence in the road corridor will be decreased up to 11% if other factors are kept constant (see equation 6).

c)Terrain, this has the coefficient -0.439, the negative sign shows that having much flat terrain in the road corridor than sloped terrain tends to reduce the occurrences of crashes which make sense. It was observed from observations of traffic safety inspections that flat terrain account larger percentage (about 90 % of the total corridor length) than a sloped terrain. From normal reasoning, sloped terrain is more dangerous to the occurrences of crashes and hence for the situation observed it is vivid that there will be the decrease of crashes. It is predicted that crash occurrences will have a positive impact to the BRT corridor such that the amount of crashes will be expected to be reduced by 6.4%. Similarly this result is according to equation10.

d)Number of intersection, this has the coefficient 0.206, the positive sign show that having many intersection in the road corridor tends to increase the chance of crash occurrence within the road corridors. The crash data as collected from police stations has proved this because those segment links having intersection within has observed with large number of crashes than a road segment without intersection. Other researcher described the correlation between crash occurrences and intersection and found that intersection increase the chance of crash occurrences. The study by [12] using negative binomial regression in Mexico city BRT system, and Bogota BRT system have described the intersection as a key factor for increasing number of crashes. Under this study, Table 6 shows that the crashes will be increased by 5.3% due to the change in the number of intersection while other factors are kept constant. The researcher used marginal effect of the predicted outcome as shown in Table 6; as indicated in the table, there is the proportionality between number of intersection and occurrences of crashes which can be obtained from the marginal effect (see equation 8).

e) Number of daladala, this has the coefficient 0.001; the coefficient is positive meaning that the number of daladala (commuter buses) has influence on increasing the chance of crash occurrences. That means the larger the number of daladala (commuter bus) the larger the number of crashes, which make sense as proved earlier from descriptive analysis showed that Morogoro road with larger number of daladala in the corridor experienced larger number of crashes. Table 6 described that there will be increase of crashes if number of daladala will be increasing or vice versa. The model predicts about 29.4% decrease in commuter bus crashes if 1400 daladala will be removed as stated by DART agency in previously section of data collection. The marginal effect for this variable as indicated from Table 6. Using derivatives from this table and knowing the number of daladala to be removed from the corridor helped the researcher to predict the occurrences of crashes given that other factors kept constant (see equation 7).

f) Lastly number of driveways, this has the coefficient-0.182, the coefficient is negative which means that number of driveways in the road corridor reduce the chance of crash occurrence. The factor make sense because driveway tends to reduce the traffic congestion in the road corridors and therefore the corridor tends to have few traffic which in fact reduce the chance of crash occurrences. As indicated from marginal effect Table 6 above, it found that there will be the reduction in crash occurrences by 10% due to the number of driveway in the road corridor if other factors are kept constant (see equation 9)

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The general overview from the discussion of findings shows that the inversion of BRT as a new means of public transport will tends to improve traffic safety along the road corridor by lowering the occurrences of crashes. The findings show that the occurrences of crashes are expected to drop by 39.5%. The value 39.5% is the combined influence from all factors however if we look on each factor independently, some of the factor found to lower the chance of crash occurrences while other factor increase the chance of crash occurrences. For instance, the reduction of number of daladala in the BRT corridor will lower the occurrence of crashes by 29.4%, again the number of intersection along the road corridor will contribute to the increase of the commuter bus crashes by 5.3%. On other hands the nature of terrain has seen to reduce the occurrence of crashes by 6.4%. Other factors are number of driveways along the BRT corridor which seen to contribute to the reduction of commuter bus crashes by 10%, Number of lanes has seen to be a significant factor such that if other factor kept constant it will increase the chance of crash occurrences by 12%. Lastly walkway has seen to decrease commuter bus crashes by 11%.

5.2 Recommendation

Finally, the findings of this research pave the way for the government to understand the significant of BRT project particularly in area of traffic safety. It is very clear that BRT schemes are one of the best solutions in improving public transport in any city. Other study by [12] stated that crashes had been reduced on average by 46% on the Macrobus BRT corridor in Guadalajara. Due to the findings of this study, the researcher would like to recommend that the government should speed up to continue with construction with other phases in order to facilitate proper and safe public transport to the people particularly in Dar es Salaam.

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