Economic Benefit of Introducing a Bus Rapid Transit (BRT) in Kano State Nigeria

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Abstract. The objective of this study is to know the variables use in quantifying economic benefits of public transport project, contribution of public transport to economic productivity This paper attempts to provide a Road User Cost (RUC) comparison of current usage of Buses and Cars in three different stages which are the present time, do nothing and the introduction of new modes. Vehicle operating cost (VOC), value of time (VOT), pollution cost, accident cost and environmental cost are calculated in other to know the benefits for their abilities to ensure accessibility and mobility, reduce accidents and reduce environmental loss. The study stretch involves an 11.1 km of 2-lane divided carriageway road connecting Kabuga bus stop to Janguza market. Social costs which included accident costs, accident cost of cars (private modes) were found to be 50 times the accident cost of bus accidents. California Air Resource Board (CARB) model was adopted to evaluate Environmental costs. The total road user costs were then obtained to provide comparative evaluation among the study modes. Furthermore, the multiple future scenarios were created to provide understanding about the need for inclusion of other modes. In this regard, this paper provided a framework for the cost evaluation for an urban area and results indicate that buses are more cost-effective in transportation of equivalent number of passengers.

1. Introduction

Public transportation services (also called Public transit or mass transit) are important in many ways. They provide mobility, can shape land use and development patterns, generate jobs and enable economic growth, and support public policies regarding energy use, air quality and carbon emissions. The choice of a public transport project is about a city's future, will there be congestions? Will there be high levels of noise and air pollution? Will transport be affordable? Who will be able to use the public transport? Building more roads does not reduce traffic. New roads = more cars = more traffic! The only way to reduce cars on the roads is to offer an alternative. The quality of public transit, and the degree it is integrated into a community, significantly affects travel activity. As service quality improves and communities become more transit oriented, residents tend to own fewer vehicles, drive less and rely more on alternative modes (walking, cycling and public transit) than they otherwise would [1-5]. In the past decades, Nigeria saw a tremendously increased in private vehicle ownership which is partly due to the economic growth, rapid urban development, population growth and inadequate public transport availability and services. As a result of that majority of the personal used private cars, the most of transportation resources (money and land) are devoted to private mode of transportation and their facilities. This result in increased traffic and various conflicts. The resulting growth in vehicle traffic creates various problems, including congestion, high road and parking facility costs, costs to consumers of owning and operating automobiles, traffic accidents, inadequate mobility for non-drivers, and various environmental impacts. In recent years many experts and citizens have advocated diversifying Nigeria transport systems by increasing support for alternatives modes such as walking, cycling and public transit [5-9]. The difference between a bus system and BRT is that, BRT operates longer buses on dedicated bus lanes thereby making passengers get a regular, faster and congestion-free drive. It is pertinent to stress here that, BRT has been adjudged by transport planners and policy makers all over the world at providing quality urban transportation services as it will help in tackling the huge public transport and pollution predicaments that besiege the city, thereby, enhancing good transportation quality and an improvement in the standard of living of the commuters. Because BRT system is a relatively new mode of public transit, and despite a gap in literature and a lack of documented case studies on transit impact, the emergence of BRT provides a unique opportunity to change negative perceptions regarding public transit [10-13]. Traditionally, passenger cost saving in public transportation usage was often the primary factors considered as the benefits of public transport project. Transport assessment are not limited to vehicle operating cost (VOC), value of time (VOT), pollution cost, accident cost and environmental cost as given in the paper. In an urban conglomeration these tools are used to provide rationale in the selection between private and public mode of transportation. Moreover, the correlation and assessment of the overall sum of transportation cost would require multiple and detailed indicators to cause sharp variations in the selection as well as prioritization. This paper has documented the results based on the total costs with limited indicators: Road User Costs (RUC), Environmental costs and Social costs. The cumulative costs can be viewed as a Cost Performance Package. In this attempt, the paper presented a framework to estimate and compare costs that are involved in public and private travelling.

2. Methods

Economic analysis of public transport projects should consider all significant benefits. As much as possible these benefits should be quantified and monetized. Various techniques can be used to monetize non-market benefits that involve goods which are not normally traded in a competitive market. Some benefits are unsuited to monetization or resources are not available to perform monetization analysis in a particular situation. In this study attempt was made to quantified and monetized the following benefits:

i. Value of time (VOT)
ii. Vehicle Operating Cost (VOC)
iii. Accident Reduction
iv. Emission Reduction

The method adopted is to measure the benefits and monetized them for the present condition (base year, 2015) [13-17], assume the present condition continue until 2020, measure the benefits and monetized them and finally assume a new mode is introduce, the benefits are then measured and monetized. Comparison is made amongst the options and the actual benefit if any of the introduced mode is evaluated.

2.1 Study Area

Case study area of public bus is conducted at Gwarzo road, which is starting from Kabuga bus stop to Janguza (Figure 1). The route length of origin and destination point is 11.1 km.

2.2 Data Collection

Primary data is a term for data collected from a source. Secondary data was data collected by someone other than the user. Common sources of secondary data include data collected through qualitative methodologies or qualitative research. In this project, both of data collection methods are used. For primary data are included on board, interview and questionnaire. While, for secondary data are included data from the resource room (Bayero University) and data accident from the police station. The interview had been conducted at Kabuga, Gwarzo road which is one of the operator bus management systems. Around 300 questionnaires had been distributed to the road users during they were waiting the bus. Data accident also have been used which was getting from the police station.

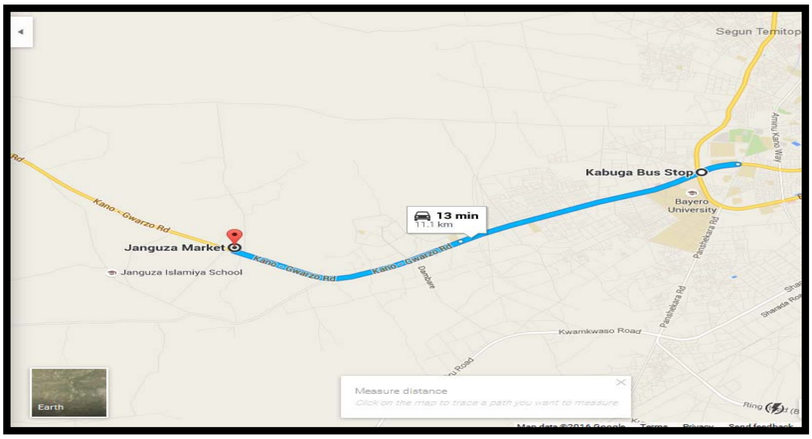

Figure 1. Case study area.

3. Result and Discussion

3.1 Estimation of Road User Costs

Road User Costs compose two costs: vehicle operating time (VOC) and value of time (VOT). Vehicle operation costs (VOC) which depends of type of vehicle and usage, including fuel, tires, maintenance, repairs, and mileage-dependent depreciation costs. While on the other hand value of time refers as the cost of time a passenger spend on journey.

The vehicle operating cost (VOC) saving is one of the technical benefits analyzed in this project. The VOC consist of the fixed cost and variable cost of the transport. Different type of transport has different cost to operate the vehicle. As presented in table 1 it can be seen that the cost for public mode is less compared to private mode. This is because the amount spent on fuel and maintenance of private mode of transport higher than that of public mode. Moreover, the cost will further reduce when the Bus Rapid Transit (BRT) mode is being introduced because there is less waiting time.

Table 1. Summary of VOC

Mode	Total VOC (2015 - 2020)
Car ($)	15,613,909
Bus ($)	509,443
BRT ($)	455,491

Value of Time (VOT) was calculated based on the level of income of individual household. A detailed study was done to find out three level of income (wage-rate method) of each household group: Low-income group (LIG), Medium-income group (MIG), and High-income group (HIG). As illustrated in figure 2, it can be seen that the VOT of person travelling on PT mode (bus) are relatively higher compared to that using private mode. This is due to the longer travel time consumed in using bus rather than car. As the new mode is introduce, there is a reduction in VOT. Average VOT ($) Person Travelling per (Day) By Local Bus and Car for The three Income Groups Considered.

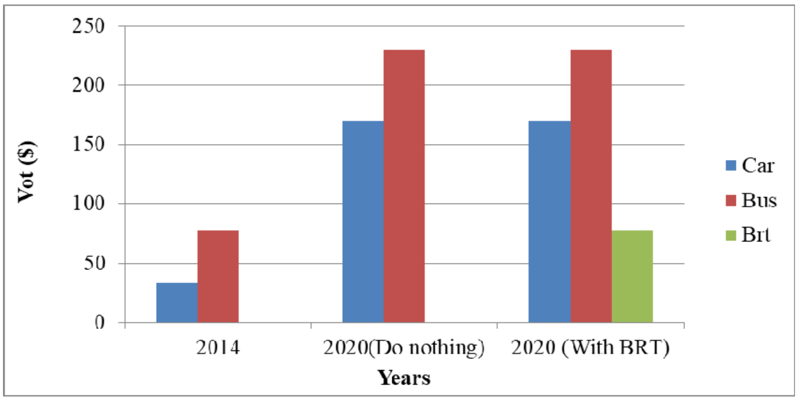

Figure 2. Comparison of 2014 and 2020 VOT with and without the new mode

3.2 Estimation of Environmental Costs

Estimation of environmental cost in transportation covers a wide range of different factors such as the impact of GHG emission, vibration and noise pollution on human beings and eco system. . For the purposes of this study, the transport-related environmental impacts that were examined based on the traffic volume in projected years consisted of: pollutants that are emitted directly into the air by the vehicles such as:

i. Emissions of greenhouse gas (GHG).
ii. Air pollutants, in particular oxides of nitrogen (NOx), particulate matter (PM10) and sulphur dioxide (SO2)

Other factors were not considered. Various methods/ models exist for estimating the environmental costs, including the use of environmental cost estimating (U.S. Environmental Protection Agency [USEPA] 2013. In this study, California Air Resource Board (CARB) model was adopted to determine the levels of the pollutants emitted (Ton) into the atmosphere. The monetary value of pollution was based on the Caltrans estimates ($/U.S. ton) of health cost of transportation emissions in 2010 rates, however, these estimates have been calibrated for Nigerian price indices for the base year 2014.

The rate of pollution has become a serious concern along with the development of Nigeria. In order to achieve sustainable development, the GHG emission of private and public transport were assessed. The assessment included the rate of carbon monoxide (CO), nitrogen oxide (NO), particulate matter (POx) and sulphur oxide produced. As it can be seen in table 2 based on the analysis, the emission rate of CO is the highest compared to other gases for both mode of transport. It can be seen that the rate of GHG for private transport is higher compared to public transport, thus the cost to reduce the emission is also higher. Furthermore, 20% increase in ridership is anticipated in the new mode. According to the Figure 3 below, for the base year 2014, the private mode pollution contribution was found to be higher than that of public mode. However, for the new mode case, it is estimated to reduce the pollutant production by about 3 times that of both the private and public mode, which means that introduction of Brt mode lead will contribute a better air quality in 2020. There will be 30% reduction in air pollution and its related costs, after introduction of development plan for in 2020.

Table 2. shows the health cost of 1 ton of different pollutant

Pollutant(ton)	Urban area ($)	Rural area ($)
Carbon monoxide	30	27
Nitrogen oxide (NOx)	6,816	5,059
Particular matter (pm10)	55,087	39,288
Sulfur oxide (SOx)	27,502	19,853
Volatile organic compound	476	374

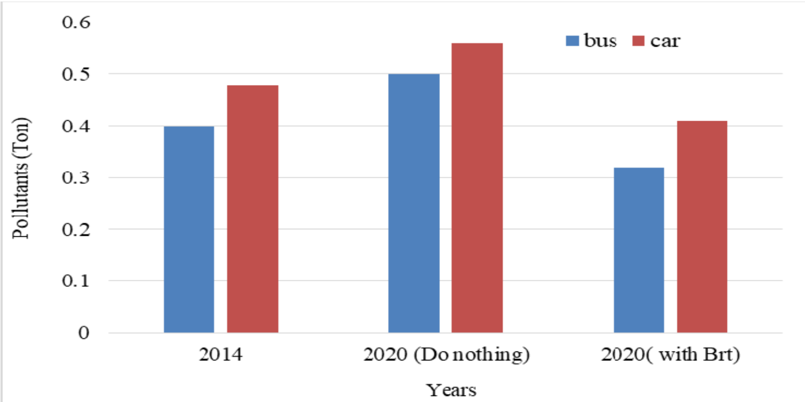

Figure 3. Total pollutant produced per ton

3.3 Estimation of Social Cost

Social costs estimation of transport accidents are deaths, major and minor injuries. In this study, the estimation of social costs is divided into two steps: first, estimating the accident statistics related to accident rate and accident frequency; and, secondly, calculating the monetary value of damage resulting from accidents. Accident rate typically is expressed as Vehicle Miles T or accidents per million vehicle travelled. The model used for calculating the crash rate for a given network is presented (1).The duration of analysis period is assumed 5 years, the length of the segment was 11.1 km, AADT was obtained from RTVM, and also, total accidents were obtained from police accident reports. The following model is applied:

$$AR = \frac{A * 10^6}{T * L * AADT * 365} \quad (1)$$

Where:

AR = number of accidents per million vehicle miles/kilometers of travel per length of segment, and per annual average traffic (in both directions)
A = average number of accident along the roadway segment for the analysis period
T = duration of the analysis period (years)
L = length of roadway segment (miles)
AADT = annual average daily traffic (in both directions)

The percentage of accident based on the vehicle types is presented in figure 4 below. It can be seen that private mode of transportation has the highest percentage 87%. This is because of the frequent involvement of the private mode in accident.

Furthermore, figure 5 below shows the comparison between the two modes of transport. It can be seen that 95 % of accidents is caused by the private modes drivers compared to the public modes drivers that is 5% of contribution to the accident. Therefore, the most contribution of accident in the case study area is private modes drivers. If the action is not being taken to reduce the number of private vehicle in the road, the road condition will become worse.

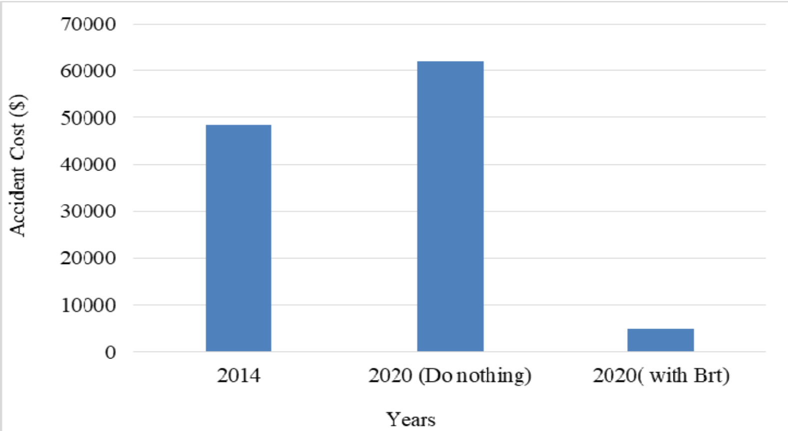

Figure 4. Percentage of accident occurs in Gwarzo road regarding vehicle classification.

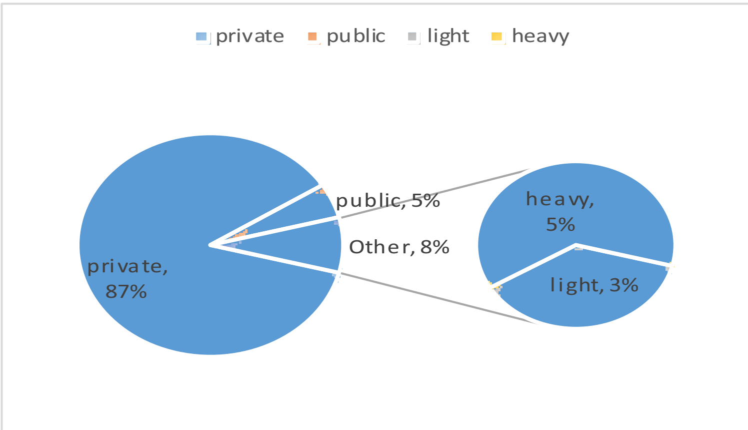

Figure 5. The accident comparison between private transport and public transport.

Safety is one of the most essential parts when discussing about public transport system. User concerns about safety when choosing the mode to travel from an origin to a destination. Therefore, the introduction of BRT in the case study area as it can be seen in figure 6 will reduce the vehicle on stretch of road without reducing the passenger's mobility. Moreover, accident condition and cost in 2014 and 2020 shows that the cost of accident will increase every year if no action is taken to solve the issue. On the other hand, the introduction of new mode will solve the issue by decreasing the accident as well as the cost.

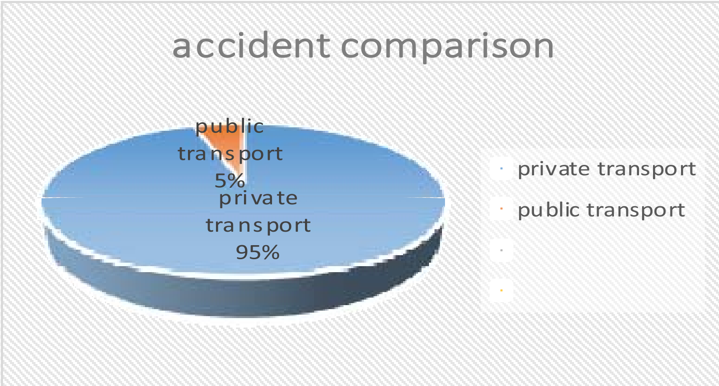

Figure 6. total accident cost with or without new mode

4. Summary

Based on this analysis, direct benefits for travelers fall into four core categories which are: (1) accident reduction benefits, (2) emission reduction benefits, (3) vehicle operating cost (VOC) savings and (4) value of time (VOT) savings.

Table 3. Summary of Economic Benefit of Case Study Area

	2014		DO NOTHING BY 2020	
	Private	Public	Private	Public
ECONOMIC BENEFIT				
Carbon monoxide				
Emission rate(g/km)	4.76	6.8		
Emission for study(g)	69.02	98.6		
Emission(ton)	7.72	0.27	9.86	0.35
Emission cost($)	227	10	290	12
Nitrogen oxide				
Emission rate(g/km)	0.52	6.54		
Emission for study(g)	7.54	94.83		
Emission(ton)	0.84	0.26	1.081	0.34
Emission cost($)	5,722	1,776	7,378	2,317
Particulate matter				
Emission rate(g/km)	0.081	0.14		
Emission for study(g)	0.261	2.03		
Emission(ton)	0.03	0.01	0.04	0.01
Emission cost($)	2,316	550	2,503	736
Sulphur dioxide				
Emission rate(g/km)	0	0.07		
Emission for study(g)	0	1.02		
Emission(ton)	0	0.003	0	0.004
Emission cost($)	2,316	550	2,503	736
Sulphur dioxide				
Emission rate(g/km)	0	0.07		
Emission for study(g)	0	1.02		
Emission(ton)	0	0.003	0	0.004
Emission cost($)	0	29610	0	39480
Total emission(ton)	8.59	0.543	10.98	0.704
Total emission cost	7,597	2,411	9,846	2,985
Total cost for both mode		20602		26,067
				Increased by **$46,669**

Table 4. Summary of Economic Benefit of Case Study Area continuation

	2014	DO NOTHING (2020)	NEW MODE (2020)		
			Private	Public	Brt
Social benefit					
AADT			1,543	350	
			8	2	
Cost of fatal accident(USD)	38,874	49,611	3,885	90	
Cost of serious injury(USD)	9,713	12,391	971	30	
Total cost of accident per year(USD)	48,533	61,935	4,853	110	
Net present value of cost (USD)	48,519	4,154	3,323	70	
		Increased by 13,434		**Decreased by 57,111**	
Technical benefit					
Vehicle operating cost					
Yearly VOC($)	**3,266800**	**4,167719**	**2,930,662**	**9,537**	**85,606**

5. Conclusion

Introduction of new mode of public transport, Bus Rapid Transit (BRT) is an essential step in order to achieve an economic development. From the analysis of this study, it's proven that BRT can reduce the cost of accident, GHG emission rate, the vehicle operating cost and the value of time saving can be achieved. Moreover, the introduction of BRT will contribute to green sustainable development and also public transport system will be trusted by the user to be used since the level of safety is high. In this context, the study is confined to given network characteristics only and is not representative for all Nigeria conditions. Similar studies must be conducted to provide a comparison between modes. Also there is a need to incorporate direct and indirect costs of transport, for further analyses.

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