Users' Perception on Sustainability of Bus Rapid Transit (BRT) System in Lagos Metropolis Nigeria

Aderibigbe, Oluwayemi-Oniya
Department of Urban and Regional Planning
University of Johannesburg South Africa
Email: oboniya@uj.ac.za

Olajide, Sylvester Oluwatoni
Lagos Metropolitan Transport Authority
Lagos State Nigeria
Email: oboniya@uj.ac.za

Abstract: *With the trends of rapid urbanization in developing cities and automobile dominance in many countries, there is a need to explore policies and plans that will allow transportation to enable quality of life for urban citizens in a sustainable manner. Mass public transportation systems, such as Bus Rapid Transport (BRT) systems, are often cited in research and planning documents as true alternatives to auto dependence for both urbanizing and developed cities. In view of this, the sustainability state of the first Bus Rapid Transits System to be designed and implemented in Lagos state, Nigeria was evaluated based on sustainable objectives in this research work. Data were collected through the use of closed ended questionnaire that was administered to a cross-section of BRT users using random sampling technique, the basics for the evaluation used was the Sustainable Transport Appraisal Rating (STAR) as designed by the Asian Development Bank ADB. Findings revealed that the overall rating of the system is marginally sustainable with the three core dimension of sustainability rated as followed; economic sustainability as marginally economically sustainable, social sustainability as moderately socially sustainable, environmental improvement as moderately environmentally sustainable, and fourth bottom line-transport system efficiency as marginally positive. Our study concludes that the system is marginally sustainable with some impacts needed to be mitigated in the operation of the route such as improvement in quality of service and reliability which will also have impact on its economic sustainability.*

Keywords*: Sustainability; Bus Rapid Transport (BRT); Pollution*

Introduction

As cities grew in the 20th century, expanded transportation networks furthered urban development but also created a series of challenges towards achieving transport sustainability. In the recent Century, along with a rise in urbanization, standard of living and rapid economic development, much of the western world experienced rapid growth and progress in the development of urban and intercity transportation systems. New technologies that allowed higher degrees of personal mobility, while new policies and infrastructure investment led to the development of extensive urban and regional transportation networks that enabled a speed and magnitude of travel that had never before existed. However, these increases in mobility have been accompanied with challenges, problems, and issues that have impacted the social, environmental and economic wellbeing of individuals and communities. Communities have been segregated by large automobile oriented freeways contributing to a variety of social issues,

while the pollution from cars that use freeways contribute to local and global environmental issue. These impacts are a by-product of the rapid development of transportation in the twentieth century, where urban form was designed and engineered to accommodate the automobile as the principle and, in some cases, sole transportation mode. With congestion and automobile dependence come increased emissions and pollution, impacts on human health, and economic hindrance, all of which are symptoms of one overarching problem: unsustainable transportation systems.Bus Rapid Transit is now widely accepted as a sustainable mass transit option that can compete and complement rail systems in delivering high-quality services. It is a high quality bus-based transit system that delivers fast, comfortable, and cost effective urban mobility through the provision of segregated right-of-way infrastructure, rapid and frequent operations, and excellent in marketing and customer service. Some of the advantages over metro systems include lower operating and capital cost, higher flexibility and shorter implementation time. These benefits have made Bus Rapid Transit more prevalent in developing countries. Hence, this study examined the perception of users on the sustainability of Bus Rapid System (BRT) in Lagos, Nigeria.

Literature Review

Sustainable Transport Planning

Sustainable transport planning refers to transport policy analysis and planning practices that support sustainable development. Sustainable development constitutes environmental, social and economic objectives. Transport policy and planning decisions can have diverse, long-term impacts. A critical component of sustainable transport planning is the development of a comprehensive evaluation program that evaluates transport system performance based on an appropriate set of environmental, social and economic indicators. (Daniel &Litman, 2011). According to Centre for Sustainable Transportation Canada (CSTC), a sustainable transport framework, allows the basic needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health with equity within and between generations. It provides central access and headway needs of individuals, associations and social requests to be met safely, offers choice of transport mode, and support a vibrant economy, limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components and minimizes the use of land and production of noise. A sustainable transportation system is that which addresses the general population's issues, i.e. as far as mobility, openness and security inside the accessible or moderate natural, money related and social assets (Akinyemi, 2000). Sustainability is sometimes defined in a limited sense, for example, biggest ecological risks like air pollution and depletion of resources faced by humanity might be neglected by conventional planning. But sustainability is increasingly defined more broadly to include the issues in Figure below.

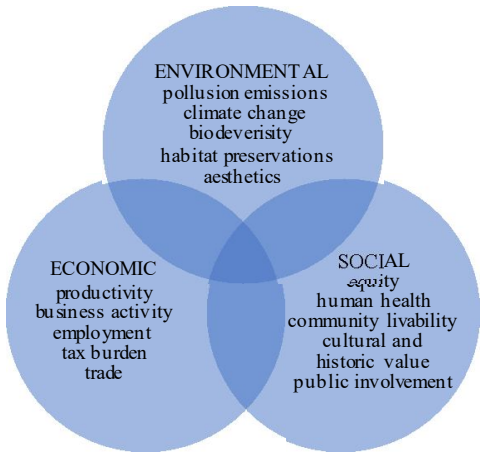

Figure 1: Three Dimensions of Sustainability

Sustainable Transport System in Lagos Metropolis

According to Lagos Metropolitan Area Transport Authority (LAMATA), (2014), Lagos has traditionally struggled with a lack of reliable mass

transit system and severe traffic congestion. The average Lagos commuter spends over three hours in traffic every day. More recently, however, the city has made strides to improve mass transit options. In 2008, Lagos introduced Africa's first bus rapid transit (BRT) system modeled on its South American counterparts in cities like Curitiba, Bogotá, and Santiago. Lagos is also pursuing sustainable transport options such as light rail, ferry, and cable car. These transport options are part of the city's efforts to reduce its environmental impact and improve climate resilience. While Lagos still has significant room to improve mobility, its multimodal approach to transport investments holds great promise for the city's commuters. In 2006, the city and state government adopted the strategic transport master plan with the goal of delivering an integrated public transit system within two decades. In accordance with this plan, Lagos became the first city in Africa to implement a BRT system in 2008. Though the system does not use all the features of some BRT systems, it still has many advantages over a traditional bus system. For example, the Lagos Metropolitan Transport Authority (LAMATA) dedicated a special lane for BRT buses along 65% of the Mile 12-Ikorodu Road corridor to reduce travel time from mainland suburbs to the central business district on Lagos Island. This BRT service has had a significant impact on transport in Lagos, and already has daily ridership of more than 130,000 passengers, despite accounting for about 4% of daily trips made in Lagos.

The role of Indicators in assessing Sustainable Transport

The overall planning process starts by using indicators, which includes consulting stakeholders, defining problems, establishing goals and objectives; identifying and evaluating options, developing policies and plans, implementing programs, establishing performance targets and measuring impacts (Litman, 2007). Indicators can reflect various levels, For example, indicators may reflect the decision-making process (the quality of planning), responses (travel patterns), physical impacts (emission and accident rates), impact on people and the environment (injuries and deaths, and ecological damages), and their economic impacts (costs to society due to crashes and environmental degradation). Indicators arise from values, therefore, the biggest advantage of an indicator-based urban sustainability assessment model is the quantify ability of the sustainability levels. Another instrumental purpose of using sustainability indicators is that, by visualizing phenomena and highlighting trends, indicators simplify, quantify, analyses and communicate otherwise complex and complicated information. Depending on these qualities, indicators have attracted a wide range of interest, and this has led to the generation of a large number of relatively successful urban sustainability assessment practices. The main difficulty faced while using indicators is to find a common unit and method of measurement leading to comparison of performance of a policy. Over the last decade, there has been an increasing effort to structure an indicator system and monitoring process to accurately formulate an integrated urban sustainability monitoring and assessment strategy (Yigitcanlar& Dur 2010).An indicator can be expressed as a variable chosen within a scope to measure the development towards a planned objective. A very important approach to measure and evaluate transport sustainability is the use of indicators. Indicators are mostly defined as quantitative measures that can be used to illustrate and communicate complex phenomena simply, including trends and progress over time" (EEA, 2005). During the last two decades measurement of sustainability issues by indicators has been widely used by the scientific community and policy-makers. Development of sustainability indicators was first brought up as a political agenda issue at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. The UNCED policy declaration Agenda 21 requested countries at the national level and international governmental and non-governmental organizations at the international level to develop indicators in the context of improving information

for decisionmaking. Since then, indicators are considered to be important tools for measurement of different aspects of Sustainability development, including transport related issues (Litman, 2007).

Criteria for Selecting an Indicator

In most situations, no single indicator is adequate, so a set off suitable indicators should be selected. An indicator set should reflect various goals and objectives. Indicators should be carefully selected to provide useful information. Quantitative policy targets for sustainability transport are presented as additional useful criteria for the selection of transport indicators. In general, indicator quality criteria reflected in the policy documents of the international organizations commonly state that indicators must be clear and understandable, policy relevant, accessible, and reliable and the indicator data must be accurate. Most of the organizations in the European Union and World Health organization (WHO) agree that indicators should be the representatives of selected geographical or political area (Litman&Brenman, 2012). Timeliness is an important indicator quality criterion for a good assessment, taking into account the number of indicators as an important quality aspect. Litman, (2007) defined some principles which should be applied when selecting transportation performance.

- Comprehensive – Indicators should reflect various economic, social and environmental impacts, and various transport activities (such as both personal and freight transport).
- Data quality – Data collection practices should reflect high standards to insure that information is accurate and consistent.
- Comparable – Data collection should be standardized so the results are suitable for comparison between various jurisdictions, times and groups. Indicators should be clearly defined. For example, "Number of people with good access to food shopping" should specify 'good accesses and 'food shopping.'
- Easy to understand – Indicators must useful to decision-makers and understandable to the general public.
- Accessible and Transparent – Indicators (and the data they are based on) and analysis details should be available to all stakeholders.
- Cost effective – The suite of indicators should be cost effective to collect. The decision- making worth of the indicators must outweigh the cost of collecting them.
- Net Effects – Indicators should differentiate between net (total) impacts and shifts of impacts to different locations and times.
- Performance targets – select indicators that are suitable for establishing usable performance targets.

In the area of transport, as in many other fields, indicators play a useful role in highlighting problems, identifying trends, contributing to priority setting, policy formulation and evaluation and monitoring of process, in this way informing the public and decision-makers.In summary, comprehensive criteria defining sustainability transport system may help to define the scope of indicators for measurement of transport sustainability performance and may provide with the more complete overview of various aspects of transport sector (Barrella, 2012).

Table 1: Objectives, criteria and indicators for the overall assessment

Sustainability Goals	Objectives	Performance Indicators
I. Economic Economic productivity	Transport system efficiency. Transport system integration. Maximize accessibility. Efficient pricing and incentives	Per capita GDP and income. Portion of budgets devoted to transport.
Economic development	Economic and business development	Access to education and employment opportunities. Support for local industries.
Affordability	All residents can afford access to basic (essential) services and activities.	Availability and quality of affordable modes (walking, cycling, ridesharing and public transport). Portion of low-income households that spend more than 20% of budgets on transport.
II. Social Equity / fairness	Transport system accommodates all users, including those with disabilities, low incomes, and other constraints.	Transport system diversity. Portion of destinations accessible by people with disabilities and low incomes.
Community development	Help create inclusive and attractive communities. Support community cohesion.	Land use mix. Walkability and bikability Quality of road and street environments.
Cultural heritage preservation	Respect and protect cultural heritage. Support cultural activities.	Preservation of cultural resources and traditions. Responsiveness to traditional communities.
III. Environmental Prevent air pollution	Reduce air pollution emissions Reduce exposure to harmful pollutants.	Per capita emissions of local air pollutants (PM, VOCs, NOx, CO, etc.). Air quality standards and management plans.
Prevent noise pollution	Minimize traffic noise exposure	Traffic noise levels
Open space and biodiversity protection	Minimize transport facility land use. Encourage more compact development. Preserve high quality habitat.	Per capita land devoted to transport facilities. Support for smart growth development. Policies to protect high value farmlands and habitat.

Research Method

Study Population

The targeted population for this research are the BRT users along the Ikorodu-TBS, Oshodi, Yaba/ Oyingbo and Ikeja route, it is a two way traffic flow directions that run from the Lagos suburb to the designated administrative and commercial centers (Central Business District), average ridership on the route is about 130 000 in both direction. Which means a one way traffic has approximately 65 000 passengers per day. Therefore our population size will be taken as 65,000

Sample size

Having determined the study population to be sixty five thousand (65 000) passengers, the sample size is determined using a simplified formula for proportion, in determining the sample size of this study, the Taro Yamane's formula was adopted. The formula is designed as follows:

$$n=\frac{N}{1+N(e)^2}$$

Where n is the sample size, N is the population size (in this case, population size is 65 000) and e is the level of precision (in this case, it is assumed to be 7%)

7% is chosen as our sampling error or level of precision as it implies that any result from this research work has a ± 7% range for the true value.

Applying this formula, sample size, n= 203.

Sampling Techniques

This research employed the use of a structured questionnaire to elicit relevant information on the, demographic, socio-economic and travel characteristic of respondents, rating of selected indicator based on social, economic, environmental and system efficiency dimensions as perceived by the users. The questionnaire was administered at different BRT bus stops and terminals along the Ikorodu-TBS corridor within a period spanning a week. From the total of two hundred and fifteen (215) questionnaire that was administered, a total of two hundred and eight (208) questionnaires was filled and returned while two hundred and three (203) questionnaires was found usable for analysis. Forty questions were captured in the questionnaire, ranging from the socio-economic and travel characteristics, scaling of social, economic, environmental and system efficiency of the BRT and respondents were randomly selected.

Descriptive method of analysis was used in describing the demographic, socio economic and travel characteristics of passengers, while the sustainable transport appraisal rating (STARS) as designed by the Asian Development Bank ADB, (2014) was used in the rating of social, economic, environmental sustainability and system efficiency of the BRT as perceived by passengers using a 5.0 scale.

Sub Criteria and Overall Rating

After the evaluation of each sub criteria average score, the score will be assigned with a corresponding descriptor that makes a basic of the deduction of the impact or influence of the indicator involved which will be used in the description of the sub criteria, in this case, the score are from 5-1 with 1 the lowest and 5 the highest, in most cases, the mean score was then assigned to the descriptor nearest to the estimated whole number to get a proper descriptor using the basic approximation knowledge. The overall rating of each dimension will be the result of all average of all sub criteria under each category and each average score will be assigned with a descriptor as showed in the table of descriptor.

Table 2: Sub criteria rating descriptor

SCORE	DESCRIPTOR	MEASURE
1	Strongly negative	Strongly negative impacts. May be short-, medium-, or long-term impacts and will most likely respond to management actions.
2	Moderately negative	Moderately negative impact, probably short-term, able to be managed or mitigated and will not cause substantial detrimental effects. May be confined to a small area.
3	Neutral/Marginally positive	No discernible or predicted positive or negative impacts.
4	Moderately positive	Moderately positive impact, possibly only lasting over the short term. May be confined to a limited area.
5	Strongly positive	Strongly positive impact, possibly of short-, medium-, or long-term duration. Impact may not be absolute but only perceived in comparison to the base case.

Analysis and Discussion

Socio-economic and Travel Characteristics of Respondents

The gender, age group, level of education, occupation, and car ownership distributions of the sample population was analyzed and discussed under the socio economic characteristics of the respondents while origin and destination of trip purposes, number of time respondents use BRT per day, other modes used for the trip purpose, and mode choice used to complete trip, trip route and estimated travel time was analyzed and discussed to understand the travel pattern of respondents as regards the BRT corridor of the selected route.

Gender

Our findings revealed that there were (114) male respondents which represents 56% of the total respondents and eighty-nine (89) female respondents representing 44% of the total respondents as shown in the figure below. This indicates that there were more BRT users than the females, hence corroborating the study of Olowosegun et al. (2014) who found the male gender as the dominant users of BRT in Lagos Nigeris

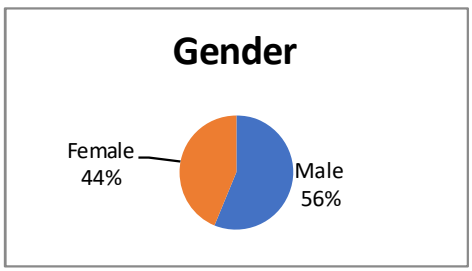

Figure 1: Distribution of Respondents by gender

Source: Author's Field survey 2022

Age Distribution of Respondents

It was discovered from the study that most BRT users are aged between 25 and 54accounts for 78% of total respondents (see fig. 2), and these are the typical working class/independent age group who often require distant travel to access opportunities in the metropolis. Respondents aged between 15 and 24 constitute about 19%. The Dependent age group (above 55) and (15 or less) were the least users pr patronize of the BRT system. This is expected because children typically enroll in schools within walking distance to their residents and most seniors are retired, therefore reducing the need for regular long commute due to their aging health.

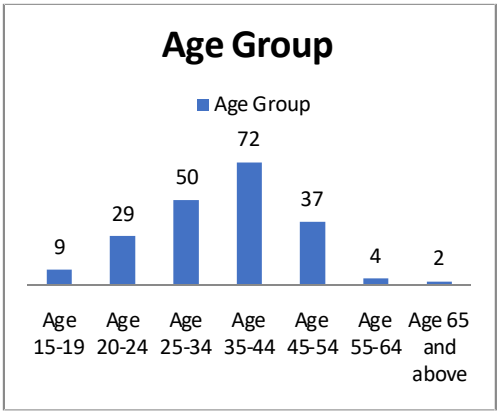

Figure 2: Agewise distribution of Respondents

Source: Author's Field survey 2022

Level of Education

Of the sampled users presented in figure 3, 42% of respondents possessed at least a university degree while about 24% hold either OND/NCE, 18% have an equivalent of secondary school education, 4% Primary school education, 9% possessed master's degree, 2% possessed PHD in their field while a little of the sampled respondent about 1% had no formal education. Most of the sampled respondents had heard or know about sustainable development in a way or the other which was deduced from personal interview with some of the respondents and also as evidenced that an average respondent as seen observed our findings was educated.

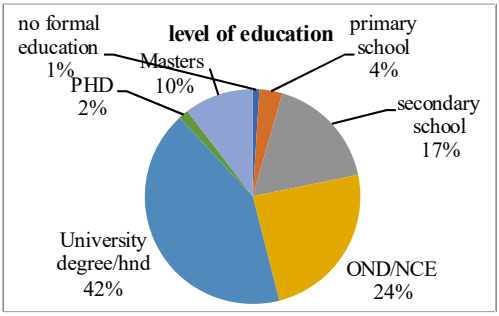

Figure 3: Educational Level of Respondents

Source: Author's Field survey 2022

Occupation

As presented in Figure 4, majority of respondents are the working class group that require more trip to access various opportunities, they are the self-employed, civil-servants, trader or and artisans which represent 86% of the total respondents; followed by students 11% that make trip to their various educational institution and other functional places while others as an option in this category account for the remaining 3% that probably account for unemployed or retired respondents.

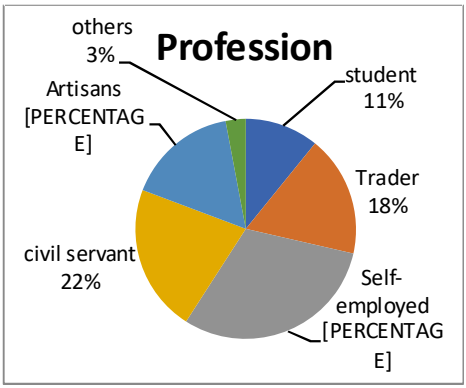

Figure 4: Occupation wise Distribution of Respondents

Source: Author's Field survey 2022

Car ownership

Number of car ownership ranges from zero (0) – two (2). From the analysis, it was discovered that one hundred and twenty seven (127) respondents representing about 63% of total respondents do not have own a private vehicle, hence the use of BRT. This categories can be described as captive users and others are choice users that have a car to two to make their trip but prefer to use the BRT for their trip purpose.

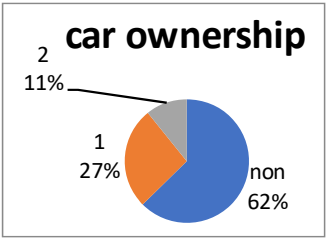

Figure 5: Car ownership

Source: **Author's Field survey 2022**

Travel Characteristic of BRT users

This section of the analysis deals with respondent's trip purposes (origin and destination), trip frequency, mode of transport used to access and complete trip, trip route and estimated time. This aids in understanding the trip characteristics of the BRT users.

Trip Origin and Destination, Trip frequency, Trip distance and Time

From our study, it was discovered that most trips originated from homes and offices as most users make use of the BRT to access the commercial, industrial and administrative centers of the city and also use the system on their return journey, this split reflects the importance of the BRT system to the economic sector in Lagos. The system also helps to meet shopping, religious, health and educational purposes. Furthermore, most users use the BRT service twice (to and fro) of their activities, this indicates that most of the respondents are conversant with the BRT system, thus increases the significance of their perception. In addition to this, most of the bus stops and terminus are accessible by walking, tricycle, motorcycle and other public transport means (first mile last mile services), it was observed that most of the users use the BRT system for journey with a minimum of about 13 km that usually last for about 20 minutes at minimum. From our study

the average travel time is about 45 minutes, with trip spanning through different routes.

As observed, morning (AM) peak period is experienced on the south bound of the corridor as terminus and bus stops along this bound is crowded from 6:00hrs to 10:00hrs,then comes the ease that is more or less an off peak period on the corridor around 11:hrs to 14:00hrs. The afternoon (PM) peak period is about 15:00hrs to 20:30hrs as a result of return trip from work place and other activities.

Sustainability Assessment of the BRT System

System Efficiency

Quality of service and reliability of the system (see table 3) are majorly considered under system efficiency category in the assessment of passenger's perception on the BRT system using the Sustainable Transport Appraisal Rating concept. Indicators such as speed, comfort, waiting time at the bus stops and system identity are evaluated as a sub criteria of quality of system and it was evaluated to be marginally positive with a mean score of 3.051 while users perception about reliability of the BRT sysyem at the period of survey showed that it is moderately negative with a cumulative score of 2.387 as indicators such as frequency of bus arrival and departure, service timing and users journey planning with the system schedule are evaluated under the category of reliability. The overall system efficiency was then evaluated to be marginally positive with a mean score of 2.647 out of a total of 5

Table 3: Respondents rating of each variables of system efficiency and mean score calculation

	1	2	3	4	5	Summation of the score(∑Fi*Si)	Mean score	Descriptor
Quality of service								
Speed	27	34	73	39	30	620	3.054	Marginally positive
Comfort	9	11	29	79	75	809	3.985	Moderately positive
Waiting time at the bus stop	80	53	41	19	10	435	2.143	Moderately negative
System image and identity	13	58	63	47	22	616	3.035	Marginally positive
Mean score of quality of service							**3.051**	**Marginally positive**
Reliability								
Frequency of bus arrival	56	70	56	14	7	454	2.236	Moderately negative
Frequency of bus departure	37	61	56	43	11	549	2.704	Marginally positive
Service timing	58	77	37	24	7	454	2.237	Moderately negative
Users journey planning with the system schedule	49	56	63	23	12	502	2.273	Moderately negative
Mean score of reliability							**2.387**	Moderately negative

Source: Field survey, 2022

Economic Sustainability

The overarching purpose of sustainable development is to guide economic activities in a direction that ensures sustainability of resources for existing and future generations. Hence, travel time, employment generated and affordability was selected for economic sustainability analysis of the BRT system, and based on passenger's rating, employment generation was rated marginally positive with a cumulative mean score of 3.318 as both the employment opportunity generated by the BRT system and access to city's employment has a notable effect on passengers, with evidences that the system span through many

commercial, administrative, and industries locations, connecting commuters with various job opportunities and as well generating job opportunity to different profession working with the operator and contractors of the service.

Travel time saved on transits as presented in table 4 has a mean score of 3.773 and is the most single indicator rated moderately positive as more time is being saved on transits but the time saved at bus stops with 2.371 (moderately negative) brings the reduction in travel time low to an average of 3.072(marginally positive) as more time is being spent at the bus stops waiting for the arrival of the buses which has effect on the overall travel time saved. Affordability of the system has a score of 3.335 which translate to be marginally positive, The bus fares is relatively affordable to be paid by all classes of users as the system is charged base on zoning system using an e-ticketing technology which doesn't discriminate and the transport budget per household is less than 20% of their disposable income on the average.

Table 4: Respondents rating for each variables of economic sustainability

S/N	1	2	3	4	5	Summation of the score(∑Fi*Si)	Mean score	Descriptor
REDUCTION IN TRAVEL TIME								
Travel time saved on transits	11	24	38	57	73	766	3.773	Moderately positive
Travel time saved at bus stop	51	71	64	9	8	461	2.371	Moderately negative
Mean score of reduction in travel time							**3.072**	**Marginally positive**
EMPLOYMENT GENERATION								
Employment opportunity generated by the BRT system	27	18	91	36	31	635	3.128	Marginally positive
Access to city's employment opportunity	6	31	55	71	39	712	3.507	Moderately positive
Mean score for employment generation							**3.318**	**Marginally positive**
AFFORDABILITY								
Bus fares affordable to be paid by all classes of citizens	25	23	64	36	54	677	**3.335**	**Marginally positive**

Source: Field survey, 2022

Social Sustainability

This describes the extent to which project impacts will accrue to the poor, and those vulnerable and marginalized, strengthen social cohesion and encourage the use or shift to public transport. In this study, the result in table 5 showed that the overall rating of the social sustainability is moderately sustainable with equity/fairness rated "moderately positive" with 4.005 mean score; transport users perceive a step increase in the accessibility to basic services because either (i) people regardless of gender or social status for example women, children, the elderly, or people with physical or mental impairments, and ethnic and/or religious minority groups benefit from the service/system without discrimination or restrictions, (ii) the reduction in actual transport costs is moderate, or (iii) accessibility is improved by consideration and provision of necessary facilities for people of different categories such as low floors, high contrast coloring, handrails, ramps/lifts, visual and audio communication facilities for users both at bus stops and on transit. This allow all users to take advantage of the transport service.

Nevertheless, even with high rating in this core dimension, the system still get a neutral rating which is marginally positive in the sub criteria of increase in use of public transport with mean score 3.426, this shows that there are some factors that discourage the choice users not to really make use of the BRT system as the waiting time and frequency of bus arrival is low, as well as low rate of operational buses on the corridor, the tendency to increase in use of public transport and the encouragement of use of public transport as a sub criteria in this dimension has a mean score of 3.355 and 3.498 respectively (moderately positive).

Accessibility been rated as moderately positive with a mean score of 3.559 as proximity to human settlement, walk able and cycle able access to bus stops, access to the system by disable get 3.434(marginally positive),3.744(moderately positive) and 3.498 (trends towards moderately positive) respectively.

In conclusion, Social impacts such as equity and accessibility are moderately positive and they are partly offset by marginal positive impacts like the increase in use of public transit thus making the social sustainability of the system moderately sustainable.

Table 5: Respondents rating from each variables of social sustainability and mean score calculation

S/N	1	2	3	4	5	Summation of the score(∑Fi*Si)	Mean score	Descriptor
EQUITY/FAIRNESS								
System accessible by all users including those with disabilities	13	11	37	46	96	813	4.005	Moderately positive
Mean score of equity/fairness							**4.005**	**Moderately positive**
ACCESSIBILITY								
Proximity to human settlement	10	32	54	66	39	697	3.434	Marginally positive
Walk able and cycle able access to bus stops	6	42	21	64	70	760	3.744	Moderately positive
Access to the system by the disabled	12	31	58	48	54	710	3.498	Moderately positive
Mean score for Accessibility							**3.559**	Moderately positive
INCREASE IN USE OF MASS TRANSIST								
Increment in use of public transport	15	50	38	48	52	681	3.355	Moderately positive
How well does the system encourage more users	21	27	36	68	51	710	3.498	Moderately positive
Mean score for increase in use of public transport							**3.426**	**Marginally positive**

Source: Field survey, 2022

Environmental Sustainability

Environmental outcomes of the project is measure in terms of contribution to emission loads (greenhouse gases, pollutants and noise), impacts on the natural and built environment, and safety for users which is also seen as a social factor, high rating as regards users less affected with noise from the system both on transit and at bus stops is rated moderately positive with 3.799 as there is a moderate reduction of traffic noise along the system corridor, Noise level for commuters on transit account for 4.168 which is moderately positive as passengers and driver enjoy a low noise level during their trip, however more passengers are affected with noise while at the bus stops and terminus due to noise from hawkers etc. The mean score for this is 3.429 hence marginally positive (see table 6). Greenhouse effect also get a moderately positive rating with mean score of 3.604. Safety improvement is also moderately positive as user's perceived high sense of safety using the bus system with reduction of accidents and safety improvement on transits rated 3.892 and 3.675 respectively. Environmental impacts are strong and positive and any negative impacts are minor thus making it moderately environmental sustainable.

Table 6: Respondents rating for each variable of environmental sustainability

S/N	1	2	3	4	5	Summation of the score(∑Fi*Si)	Mean score	Descriptor
NOISE								
Users less affected by noise at the bus stops	23	21	47	69	43	696	3.429	Marginally positive
Users less affected by noise on transit	14	8	18	53	110	846	4.168	Moderately positive
Means Score For Noise							**3.799**	Moderately positive
GREENHOUSE EFFECT								
Reduction in Smoke from buses exhaust pipe	29	20	17	56	81	749	3.690	Moderately positive
Users less affected by emission from the bus	24	30	33	49	67	714	3.517	Moderately positive
Mean Score For Greenhouse Effect							**3.604**	Moderately positive
SAFETY IMPROVEMENTS								
Reduction of accidents	8	13	46	63	73	790	3.892	Moderately positive
Safety on transit Incidences on transit	7	27	50	60	59	746	3.675	Moderately positive
Mean score for safety improvement							**3.784**	Moderately positive

Source: Field survey, 2022

Overall Sustainability Rating

With different effects and impacts from the system efficiency, social, economic and environmental sustainability, the BRT system has contributed significantly to the economic and social development with environmental improvement of traffic condition along the Ikorodu to TBS route which make the result of this study being considered as 'marginally sustainable 'with an aggregate rate score of 3.347 (see table 7).

This rating is given to projects or programs where positive impacts are offset by almost equally negative impacts or when the risks are high that the few positive impacts may not get delivered or sustained.

Table 7: Overall Sustainability Rating

S/N	Variables	Summation of the score(∑Fi*Si)	Mean score for core criteria	Mean score for core criteria	Descriptor
SYSTEM EFFICIENCY					
1	QUALITY OF SERVICE	2480	3.051	**2.647**	**MARGINALLY POSITIVE**
2	RELIABILITY	1959	2.243		
SUSTAINABILITY RATING					
ECONOMIC					
3	Reduction in travel time	1227	3.072	**3.348**	**MARGINALLY ECONOMICALLY SUSTAINABLE**
4	Employment Generation	1347	3.318		
5	Affordability	677	3.335		
SOCIAL					
6	Equity / fairness	813	4.005	**3.663**	**MODERATELY SOCIALLY SUSTAINABLE**
7	Accessibility	2167	3.559		
8	Increase in the use of mass transit	1391	3.426		
ENVIRONMENTAL					
9	Noise	1542	3.799	**3.729**	**MODERATELY ENVIRONMENTALLY SUSTAINABLE**
10	Greenhouse effect	1463	3.604		
11	Safety improvements	1536	3.784		
Star rating				**3.347**	**MARGINALLY SUSTAINABLE**

Source: Field survey, 2022

Further to this, Figure 6 shows the positioning of each sub criteria of the three dimensions of sustainability and system efficiency on a Sustainable Transport Analysis Rating (STAR) and the overall sustainable rating of the BRT system of the Ikorodu-TBS route as at the time the research work was carried out from user's perceptions.

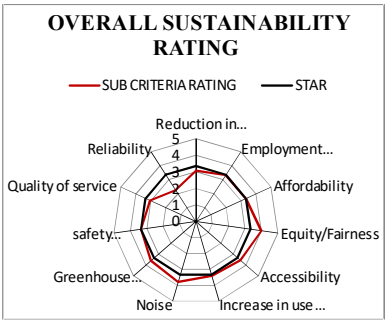

Figure 6: Overall sustainability rating of the BRT system

Factors Influencing the use of the BRT System

From the indicators examined in this research, we can deduce that some of the indicators is responsible to influence the use of the BRT system in Lagos metropolis.

Comfort: The introduction of the BRT system comes with a more presentable high technology, sophisticated modern bus that is configured to meet the comfort need of all classes of citizens while on transits, it also provide bus stops, shelters and terminus that protect users from hazardous weather, hence rated 3.984 which mean this impact is moderately positive

Speed: The bus system run has an average on the conventional unregulated bus system along the corridor as it run on its own dedicated Right Of Way (ROW) and while mixed with other traffic, there is a priority for BRT at intersection which make it more faster since it is not affected by traffic congestion. In this research work, it is rated 3.054 which implies that it is marginally sustainable.

Travel time saved on transits: Despite the fact that the much time cannot be really saved at bus stops due to low bus rollout which result in increase in headway, the time saved on transits is one of the reason users make their trip with the BRT system. Rated 3.775(moderately positive)

Affordability: the system is affordable as the system charges based on zone, it make use of the e-ticketing system that allows fares to be charged automatically by the tap in machine. The estimated percentage on money spend in using the BRT for daily commuting of an average passenger is less than 20%, thus, it was rated 3.2 which is marginally positive.

Safety and freedom from unpleasant incidence: Safety has been considered as one of the objectives of a good transport system, hence, users make their trip with BRT as they experience safety and are free from unpleasant incidents while on transits, thus, rated 3.78 and best described as moderately positive.

Conclusion

Our study adopted the Sustainable Transport Analysis Rating (STAR) to analyse passengers perception on the sustainability of the Bus Rapid Transit system in Lagos metropolis using the first BRT classic route of Ikorodu-TBS as the case study. It was discovered that while result from this research can help in planning for subsequent BRT route within the metropolis and suburb area of Lagos state to achieve a more sustainable transport system. we conclude that the system is marginally sustainable with some impacts needed to be mitigated in the operation of the route and planning for other BRT routes in Lagos State. The result from this study can help in planning for subsequent BRT route within the metropolis and suburb area of Lagos state to achieve a more sustainable transport system.

References

Akinyemi, E. A. (2000). Sustainable development and transportation: Past experiences and Future Challenges. World Transport Policy & Practice.

Asian Development Bank, ADB (2014),Sustainable Development Working Paper Series No.31 pp 24-27.

Banister, D. (2005). Unsustainable Transport: City transport in the new century. New York.

Barrella, E.M. (2012). Strategic Planning for a Sustainable Transportation System: A SWOT-Based Framework for Assessment and Implementation Guidance for Transportation Agencies. Ph.D. Thesis, Georgia Institute of Technology, School of Civil and Environmental Engineering, Atlanta, GA, USA, 2012.

Lagos Metropolitan Area Transport Authority (LAMATA), (2014). Lagos BRT Lite: Africa's First Bus Rapid Transit Scheme. Lagos BRT-Lite Summary Report.

Litman, T. (2007) Developing Indicators for Comprehensive and Sustainable Transport Planning.Transportation Research Record: Journal of the Transportation Research Board, 2017, 10-15.

http://dx.doi.org/ 10.3141/2017-02.

Litman, T. &Brenman, M. (2012). A New Social Equity Agenda For Sustainable Transportation. A paper presented at the 2012 Transportation Research Board Annual Meeting Paper 12-3916. Assessed May 15 2016 from file:///Users/macbook/Downloads/A New Social Equity Agenda For Sustainable Transpo.pdf

Moavenzadeh, F., Hanaki, K., &Baccini, P. (2002). Future Cities: Dyanmics and Sustainability. Norwell: Kluwer Academic Publishers.

Newman, P., & Kenworthy, J. (1999). Sustainability and Cities. Washington: Island Press.

Olowosegun, A, Olorunfemi, S, Akinsehinwa, O &Okoko, E. (2014). An Assessment of Public Transport Security and Safety: An Examination of Lagos Bus Rapid Transit (BRT), Nigeria. Civil and Environmental Research, 6(4), 105-116.