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ANALYSIS OF THE OPERATIONAL DATA OF A PUBLIC TRANSPORTION SYSTEM: A CASE STUDY OF THE BUS RAPID TRANSIT (BRT), LAGOS STATE, NIGERIA

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Abstract: This paper assesses the operational data of a public transportation system, using the Bus Rapid Transit in Lagos State as a case study. Demographic data was collected through the administration of questionnaires to the commuters; this was carried out to observe variations in the population of the commuters from different perspectives. Some other categories of data were collected which include boarding and alighting, headway, arrival rate of commuters, waiting time of commuters and travel time data. These data were presented and analysed with MS Excel and Minitab statistical softwares. Results from the boarding and alighting data showed bus stops with high flux of commuters, these were at Ojota, Ketu, Mile 12, Costain, CMS and TBS. Probability distribution charts were prepared to analyze the remaining sets of data. This was carried out to study the distribution and consistency of the data. Coefficients of variation for the data were also estimated to study the variability of the data. From the study, the data followed normal distribution and they were consistent such that they can be used for further analysis of the system. It can be concluded that the distribution depicts the real situation at the study location. Thus, bus stops with high density of commuters should be provided with more buses so as to reduce the waiting time of commuters.

Keywords: Operational data; public transportation system; demographic data; commuters; headway

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INTRODUCTION

Transportation is vital both to the economic success and to the quality of life in urban and rural areas. It is a requirement for every nation regardless of its industrial capacity, population size or technological development (Somuyiwa, 2008). The rapid growth of city populations and corresponding vehicle kilometer of travel, commerce and transportation infrastructure has generated negative effects such as congestion, deterioration of air quality, noise, and motor vehicle crashes. Movement of people and goods is essential for the daily activities of man. A city with such population density and commercial activity must have an efficient transport system to perform its daily activities and withstand challenges that may arise due to traffic congestion. Lagos being the most populous city in Africa evidently shows how functional the public transportation system should be. With a current estimated population growth rate of 6% (LAMATA, 2013), there is need for an efficient transportation system. Efficient transportation provides an adequate means of moving large number of people with considerable flexibility in order to meet demand throughout the city (Wright, 1999). It plays a key role in shaping urban and rural landscapes through its influences on the form and size of settlements, the style and pace of life by facilitating trade, permitting access to people and resources and enabling greater economies of scale (Santhakumar, 2003).

Mass transportation which is the movement of large number of people, goods and services is inevitable for the socio-economic and cultural integration of nations. For this reason, the issue of mass transportation has attracted the attention of several administrations in Nigeria. In January 1989, the Federal government launched the mass transit program to enhance the transportation system in the country. Nevertheless, attempts at evolving a meaningful mass transportation system in Nigeria have been elusive. A number of problems have plagued the nation's transport industry including general inadequacy of mass transit facilities relative to demand, inefficiency in the management and running of public transport corporations and the absence of an effective maintenance culture (Adetunji, 2013).

Public transportation is critical to a nation's future. A stronger economy, conservation of energy and resources, reduced congestion, less global warming and improved air quality and health, critical support during emergencies and disasters, increased real estate values and development, mobility for small urban and rural communities, increased access for groups of all ages and circumstances, lower health-care costs—all contribute to a better quality of life (APTA, 2007). Dodson *et al.* (2011) believe that efficient public transport networks are integral features of modern urban transport systems. Effective and cheap public transport provision will aid the growth of the nation in terms of the economy, social and environmental wellbeing leading to the urbanization of cities (Adewumi and Allopi, 2014). Public transportation has also proved to be an effective tool in combating congestion. Because of these numerous advantages that public transport offers, governments in third world countries are now becoming aware that for developing countries to be more productive, improving public transport should be one of the most pressing items on their agenda.

Bus Rapid Transit (BRT) is a transport option which relies on the use of dedicated free segregated lanes to guarantee fast and reliable bus travel. It is a high performance public transport bus service which combines bus lanes with high-quality bus stations, vehicles, amenities and branding to achieve the performance and quality of a light rail or metro system, with the flexibility, cost and simplicity of a bus system (LAMATA, 2013). Each bus used is fully air conditioned and can accommodate 42 seated passengers and about 28 standing passengers, amounting to a total of about 70 passengers. It has an entry and an exit door which are only opened one at a time when passengers want to board and alight from the bus. The bus is spacious and gives provision for persons with disabilities. It runs on separated lanes and thus makes them faster in a situation where there is traffic congestion. BRT system offers reduced traffic congestion as well as offers cheap and quality services to the low and middle class citizens. It also guarantees a fast journey within a reliable travel time. It reduces long queues at bus stops, provides clean buses of better quality and reduces the number of unregulated public transport vehicles on the road. Apart from the impact on transportation, BRT also offers job creation as well as a better environment with less pollution.

Lagos state, Nigeria is one of the most populous cities in the world and the most populous city in Africa with an estimated population of 21 million as at 2015 (W.P.R., 2015). Road traffic, urban mobility, congestion and environmental pollution in Lagos have been major challenges for many years. The Bus Rapid Transit (BRT) scheme was introduced to help reduce this problem (Amiegbebhor and Dickson, 2014). The density of the Lagos population, the inadequate level of road space, the land-use characteristics and the absence of a mass transit system, combined with poorly executed development plans and encroachments on road space, have given rise to numerous transportation problems in the Lagos metropolis (Abbas, 2007). These include increasing traffic congestion, worsening state of disrepair of roads, deteriorating comfort of road-based public transport, sky-rocketing transport fares, rising levels of road accidents and increasing rates of traffic-related emission and atmospheric pollution as well as the growing menace of motorcycle transporters and thugs. Traffic congestion is however exacerbated by the operation of minibuses and midi-buses. There is an increasing need for road-based public transport to serve the ever-growing population and this gap has been filled by the informal private sector. The number of mini-buses has increased tremendously in the last few years to the extent that there are now around 75,000 mini-buses registered in Lagos. Unfortunately these vehicles now constitute the greater cause of congestion on Lagos roads (LAMATA, 2009).

The first BRT scheme in Lagos was known as BRT-Lite. Before implementation, the highway enjoyed a wide dual carriageway varying between two and three lanes in each direction. For approximately 60% of its length it has service roads. It crosses over one of the three bridges that connect the mainland with Lagos Island, and as such the route effectively connects extended suburbs, satellite centres to the traditional Central Business District of Lagos (LAMATA, 2009). The former BRT system was operated by National Union of Road Transport Workers (NURTW) and regulated by the Lagos state government through Lagos Metropolitan Area Transport Authority (LAMATA). This BRT-Lite scheme became operational on the 17th of March, 2008. It had a BRT corridor that ran along the Ikorodu road, a key highway that makes a connection between Mile 12 and CMS and is 22km long. Preliminary engineering designs for the corridor recommended virtually continuous bilateral segregation. Breaks in segregation were made where merges and diverges were allowed to/from service roads. The BRT-Lite system is approximately 65% physically segregated from other traffic, 20% separated by bus lanes (marked in paint) and 15% mixed with other traffic. The lanes are 3.3m wide and are separated from other traffic by concrete kerbs that are 400mm high.

Following the socio-economic impacts and success of the Mile 12 – CMS BRT system, on the lives of Lagosians, particularly businesses and residents along the corridor, there have been clamour for the replication of the system along other corridors of the state. The Mile 12 – Ikorodu town BRT extension has been conceived to extend BRT service from Mile 12 to Ikorodu town while also improving the Ikorodu road network infrastructure. The existing roadway consists of a 2-lane dual carriageway linking Mile 12 area to the fast growing Ikorodu town. The corridor covers a distance of about 13.5 km, while the width of the existing road is 7.5m with central median of 2m width.

Due to mismanagement of funds, the former BRT-Lite was scrapped and a new BRT system began operation on the 12th of November, 2015. The system exists as a result of a public/private partnership between Primero Transport Services and LAMATA. The new BRT scheme is operated by Primero transport services and regulated by LAMATA. Primero is involved with the procurement of the buses, maintenance of the buses and conveyance of passengers. They employ the bus drivers and manage them. LAMATA regulates the BRT scheme, the agency represents the government in the public-private partnership. They provide infrastructures such as the BRT lane, pedestrian bridges, bus shelters, bus terminals, bus depot and offices. They also serve as an enforcement agency to ensure that the necessary transport laws are strictly adhered to in order to ensure smooth operation of the scheme.

Akpomrere and Nyorere (2013) in their analysis stated that any journey by public transport constitutes four basic elements namely; access time, waiting time at the bus stop, journey time in the bus and access time at the destination.

However, as much as the importance of public transportation was emphasised in the previous researches, proper analysis of the data of the transportation system should have been the basis for the planning of the transport network. Problems pervading urban transport sector in most developing countries range from inadequate and poor quality of infrastructures, mismatch between demand and supply to increased rate of accident. The problems are triggered by interrelated trends such as urban population growth; rapid, unplanned and uncoordinated growth of cities. Lagos State has been experiencing huge population increase in the past four decades. This is due to rural-urban migration and galloping urbanization in most developing countries. These have led to enormous challenges in terms of infrastructure provision (Basorun and Rotowa, 2012).

This research involves the analysis of the BRT scheme through the collection of operational data for better understanding of the transportation system, thus helping to produce a comprehensive data on the Bus Rapid Transit Network of Lagos state, Nigeria.

MATERIALS AND METHODS

The study area

The study area is the Mile-12 terminal of the Lagos BRT, and the route chosen for the purpose of the study is the Mile 12 to TBS route. Along the route are various bus stops such as: Ketu, Ojota, New garage, Maryland, Idiroko, Anthony, Obanikoro, Palmgroove, Onipanu, Fadeyi, Monshalashi, Barracks, Stadium, Leventis, CMS/Marina and TBS as shown in **Fig. 1**.

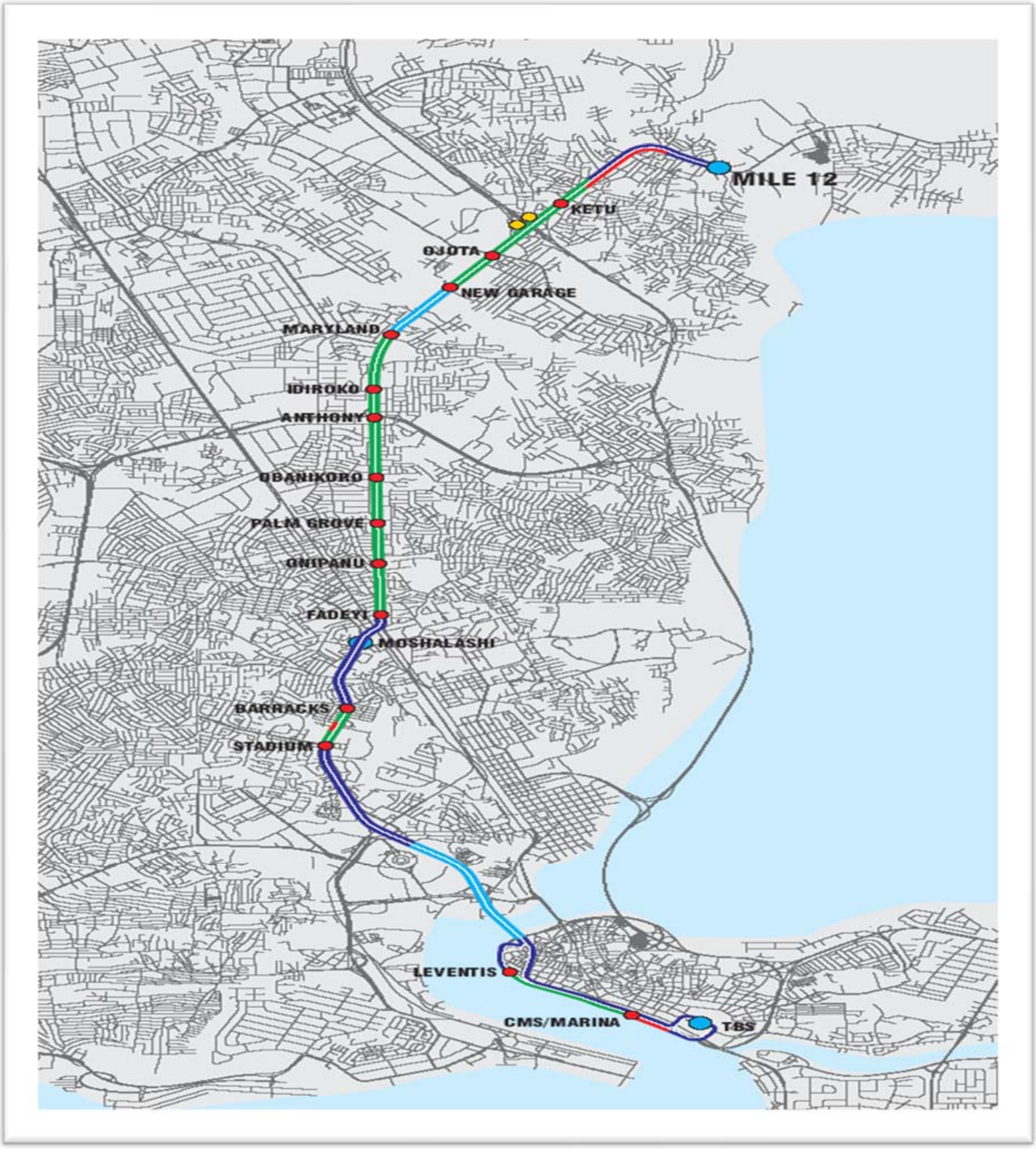

Fig. 1 Map of Mile 12 to TBS Route (Orekoya, 2010).

Data collection

Data collection for the study was carried out with the help of field survey and administration of questionnaires to respondents. One hundred and fifty (150) questionnaires were administered to commuters travelling in the Southbound (i.e. movement from residential areas to commercial centres) and Northbound (i.e. movement from commercial centres to residential areas) directions of Mile-12 to TBS route. Various field surveys carried out are as follows:

Boarding and Alighting Survey: this survey was conducted to establish the total passenger load on the bus. This is an on-board survey which requires the observer to be seated within the bus; one observer for each door in the bus. The observers records the number of passengers that board and alight at each bus stop throughout the entire journey. This was carried out for both the peak and off-peak periods. The average boarding and alighting data were computed for two weeks and plotted in a bar chart which consists of two cojoined bars representing boarding and alighting respectively.

Headway Survey: headway is the time space between two successive buses, measuring from bumper to bumper or head to head. For this purpose it is the time between the departure of one bus and the departure of the successive bus at a bus stop or terminal. The observer makes use of stopwatch and records the time between the departure of one bus and the departure of the next bus at the reference point. For this purpose, the reference point was the loading bay. The loading bay is an area where commuters queue for a while before boarding the bus.

Passenger Waiting Time: this was conducted to assess the passenger's waiting time. Waiting time of the passenger is the time interval between the arrival time of the passenger at a bus stop and the departure time from the bus stop. The observer stays very close to the queue, as the commuters come into the queue, they are chosen at random with personal identifications taken into considerations. Identification such as clothing and body characteristics were used to ensure that the data was based on each individual. Immediately the observer identified a commuter, the time at which the commuter arrived was recorded and also the mode of identification was recorded. The identification was exclusively recorded to prevent any form of confusion that may arise while the data was being recorded. This recording was carried out for six different commuters and their departure times where recorded based on the time their buses left the terminal. The average waiting time for each day was computed for both the peak and off-peak periods and the summarised table was prepared.

Bus Travel Time Survey: this was used to assess the total journey time, which is the time spent between each bus stop during alighting and boarding. This helps to check the variation in travel time and as an indicator of congestion on the route. It also indicates the level of activity at each bus stop. This, however, has severe implications on scheduling of services as well as the reliability of bus services. The observer followed the bus all through the entire journey with the aid of a stopwatch, pen and paper. The travel time between each bus stop was recorded. The total travel time was calculated and recorded for each day.

Arrival Rate of Commuters: this interprets the rate at which commuters arrive at the terminal. A time frame of five minutes was chosen and the number of commuters that arrived within this period were recorded. The observer stayed at the entrance of the ticketing queue to ensure that no commuter was missed. The stopwatch was started and the number of commuters that arrived were recorded for five minutes. This was repeated twice and the average was found. The data was recorded for both peak and off-peak periods for a period of 14days. For the analysis, a summarised table was prepared from the raw data collected on the field. The average arrival rate of the commuters for each day was calculated and recorded.

Passengers Interview Survey: for the purpose of understanding travel behaviour and user preferences, passenger interviews or opinion surveys were conducted. This was done with the use of questionnaires, the surveys was custom created to cover a variety of topics including customer travel patterns, travel behaviour, demographic characteristics, customer satisfaction, reasons for using the transit system and ways to attract increased ridership. Care was taken while interpreting the responses since it is highly subjective and the quality of information is dependent on a number of factors including the attitude of the interviewer and the respondent.

Data analysis

Data obtained from the field survey were properly organised, inputted and analysed in MS EXCEL and MINITAB statistical softwares. The data was converted into information such as descriptive statistics involving average of data, development of various charts such as bar and pie charts. Minitab was also used to generate the probability distribution of the data. From the probability distribution plot, the standard deviation, mean and the coefficient of variation were determined.

RESULTS AND DISCUSSION

Demographic Analysis

Gender: based on the analysis of commuters that made use of the BRT system via the Mile 12 terminal, 94 male respondents i.e. 63% and 56 female respondents i.e. 37% of the total respondents were observed to be using the system **Table 1**. This shows that there are more male commuters patronizing the transit system.

Age: It was observed that the highest population of commuters fell between 26 and 35years of age, with 59 respondents representing that age bracket. Age bracket between 15 and 25years accounted for 27%, 36-45years accounted for 21%, 46-55years accounted for 7% and commuters of over 55years of age occupied 5% of the respondents **Table 1**.

Academic Qualification: Table 1 shows that 43% of the commuters are BSc holders which occupies the majority. 24% of the respondents are OND holders, 30% of the respondents are SSCE holders and 3% of the respondents have no formal education. This shows a high level of literacy among the commuters patronizing the transit system.

Car Ownership: The analysis shows that majority of the commuters are not car owners with 96 respondents representing 64% belonging to this group. 54 respondents however are car owners representing 36% of the total respondents **Table 1**.

Purpose of Travel: the purpose of travelling may influence the form of transportation used by an individual. Table 1 shows that 14% of the respondents use the transit system for visits, 31% of the respondents were on a journey to their offices, 40% of the respondents used the system for personal business trips and 15% of the respondents use the system for other purposes.

Modal Choice: this highlights the choice of the mode of transportation by the commuters, taking into consideration the mode of transportation that was previously used by the commuters. 99 respondents representing 66% made use of buses as their mode of transport, 37 respondents representing 25% made use of their personal cars. The remaining 9% of the commuters however plied the route with other modes of transport **Table 1**.

Boarding and Alighting Survey

This survey analyses the demand characteristics of the route based on the actual boarding and alighting pattern of passengers at various bus stops along the route. This helps to visualize the boarding and alighting patterns in order to identify stops where there are high levels of activity. Observations from the data recorded show that during the morning peak period, there are more passengers boarding the bus along the southbound direction than the northbound direction. While for the evening peak, there are more passengers along the northbound direction than the southbound direction.

During the morning peak, in the southbound direction as shown in **Fig. 2**, it was observed that CMS terminal had the highest number of alighting commuters with 12 commuters, while TBS bus stop had the second highest number with 10 commuters. Along the northbound direction, even with light traffic during this period, most of the commuters alighted at Mile 12, Ketu and Ojota bus stops (**Fig. 3**).

For the off-peak period in the southbound direction as shown in **Fig. 4**, CMS and TBS recorded the highest number of alighting commuters. With an exception of Mile-12 terminal however, Fadeyi bus stop recorded the highest number of commuters boarding the buses. In the northbound direction, the commuters that boarded the transit system were majorly distributed between TBS, Costain and Onipanu bus stops. While Ojota, Ketu and Mile-12 bus stops recorded high number of alighting passengers as shown in **Fig. 5**.

For the evening peak in the southbound direction (**Fig. 6**), an average of 50 passengers were recorded. TBS and CMS recorded high number of alighting

Table 1. Demographic analysis of respondents

Gender		Age		Academic Qualification	
Male	Female	Age Group	No. of Respon-dents	Qualific-ation	No. of Respon-dents
94	56	15-25	41	SSCE	45
		26-35	59	OND	36
		36-45	32	HND/BSC	65
		46-55	10	No formal educati-on	4
		55 & above	8		
150			150		150

Car Owner		Purpose of Travel		Modal Choice	
Yes	No	Purpose	No. of Respondents	Type	Number
54	96	Visit	22	Buses	99
		Business	60	Cars	37
		Office	46	Others	14
		Others	22		
150			150		150

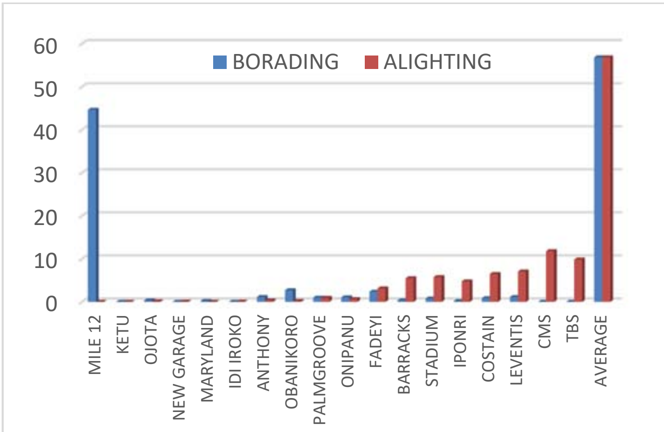

Fig. 2 Boarding and Alighting pattern (Morning peak – Southbound).

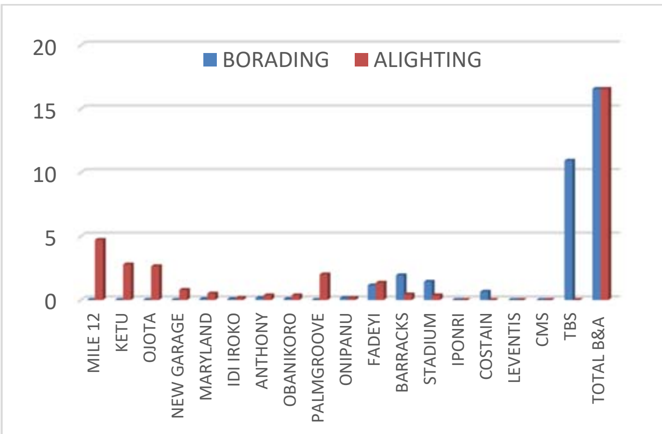

Fig. 3 Boarding and Alighting pattern (Morning peak – Northbound).

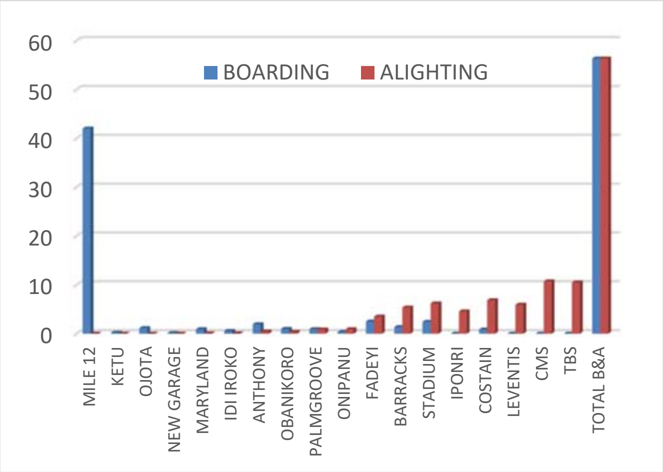

Fig. 4 Boarding and Alighting pattern (Off peak – Southbound).

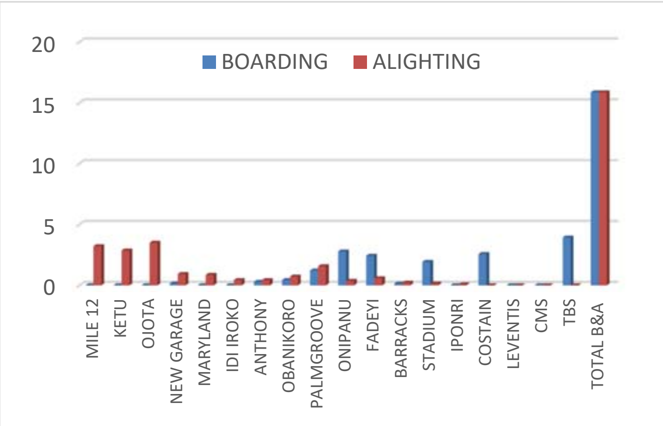

Fig. 5 Boarding and Alighting pattern (Off peak – Northbound).

commuters. While for the northbound direction, evening peak recorded the highest number of commuters with a total average of 70 commuters. Mile 12, Ketu and Ojota shared the larger part of the alighting data as shown in **Fig. 7**.

From the results above, it can be deduced that the major bus stops are at Ketu, Ojota, Mile 12, Fadeyi, CMS and TBS. These locations are always loaded with commuters. To ensure smooth operation and good performance of the system, these bus stops must be given high priority for the scheduling and rolling out of buses. This will reduce waiting time of commuters at the bus stops.

Headway

The average headway on a route is directly dependent on the number of buses plying that route and the length of the route. The standard deviation is a measure of variation from the mean and hence indicates the reliability. The reliability of a route is high if the standard deviation is close to zero, which means that the headway is constant throughout a certain time-period.

Figure 8 shows the normal distribution curve of the headway data from which the coefficient of variation, $C_v = \frac{39.29}{99.64} = 0.394$. With a coefficient of variation that is less than one, the headway data follows a normal distribution which means the data is consistent. **Figure 8** has a p-value of 0.293, hence the null hypothesis is accepted.

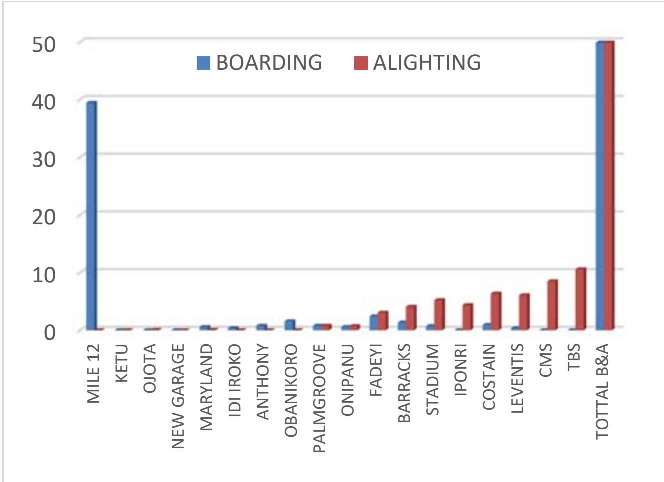

Fig. 6 Boarding and Alighting pattern (Evening peak – Southbound).

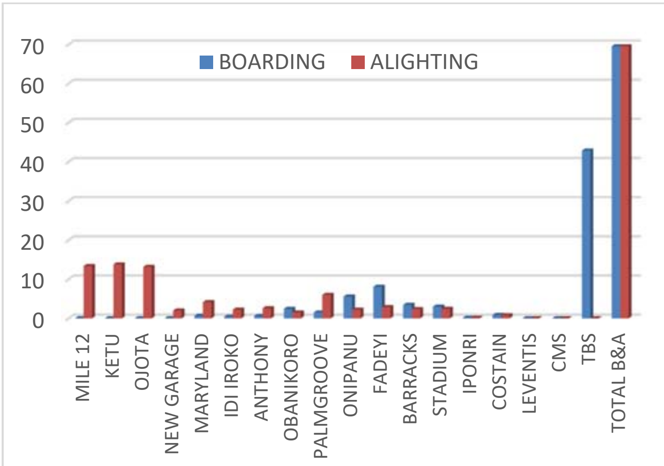

Fig. 7 Boarding and Alighting pattern (Evening peak – Northbound).

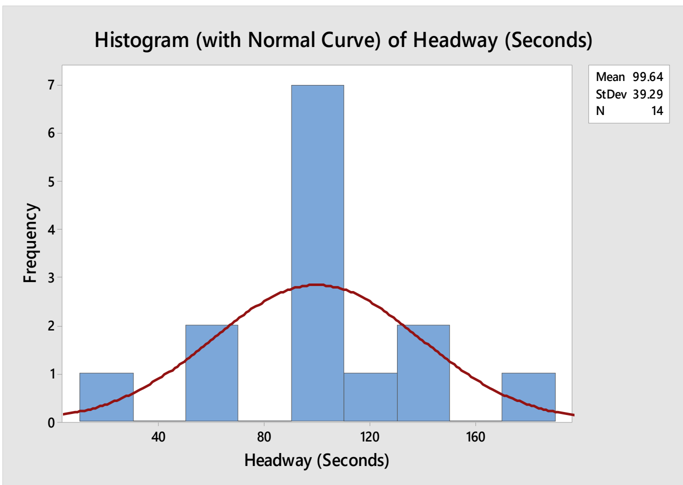

Fig. 8 Probability plot of headway (Peak).

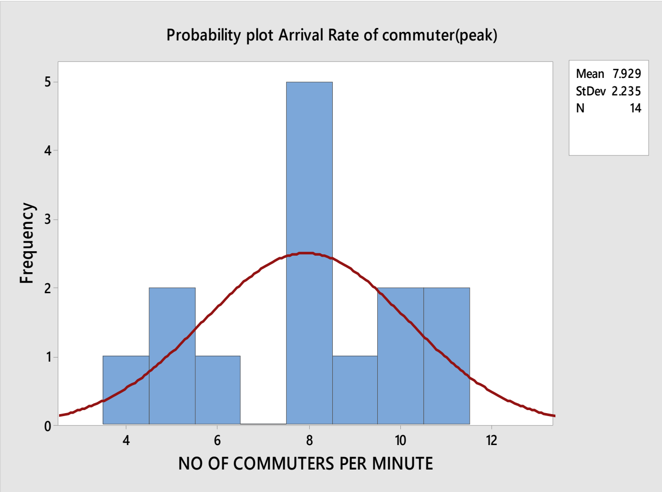

Fig. 9 Probability Distribution of the Arrival Rate (Peak).

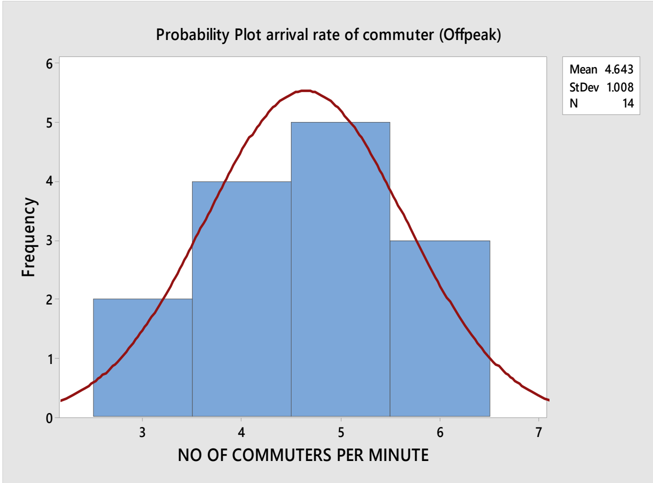

Fig. 10 Probability Distribution of the Arrival Rate (Off-Peak).

Arrival Rate of Commuters (Peak and Off-peak period)

This considers information on the rate at which commuters arrive at the terminal per unit time. This information is essential to know the rate at which the available buses will be scheduled to convey commuters to their respective destinations.

From the analysis carried out, the highest arrival rates occurred on Monday and Tuesday for both weeks for the peak period. These show how high the influx of passengers during these periods are, compared to Saturdays and Sundays which have low arrival rates of commuters (**Fig. 9**). With $C_v = \frac{2.235}{7.929} = 0.2819$ the data is normally distributed. With a coefficient of variation of 0.2819, the data is consistent. With a p-value of 0.197, the null hypothesis that the arrival rate represents the existing situation is accepted.

Figure 10 shows that the average arrival rate of commuters for the off-peak period is less than that for the peak period, due to a decrease in the number of commuters available for conveyance to their destinations. From the probability distribution curve, $C_v = \frac{1.008}{4.643} = 0.2171$, this implies the data is normally distributed along the plot with a low coefficient of variation. With the data collected and analysed through the arrival rate of commuters, it is consistent. With a p-value of 0.086, the null hypothesis is accepted.

Waiting Time

The average waiting times for the commuters and the distribu***tion plots are presented in*** *Fig.* 11. It was observed that the highest value of waiting time occurred on Mondays, this is due to the large number of passengers to be conveyed by the buses and the inadequacy of buses during this period. The high flux of commuters on Mondays led to this inadequacy and eventually resulted to a high value of waiting time during the peak period. From **Fig. 11**, the mean waiting time is 9.14 and the standard deviation is 2.98. This indicates how normally distributed the data is, with all the values aligned close to the middle line. With $\boldsymbol{C_v = \frac{2.983}{9.143} = 0.3262}$ the coefficient of variation for the waiting time (peak period) is of a low value. This shows consistency in the data. With a p-value of 0.544, the null hypothesis is accepted**.** The mean waiting time during the off-peak period is 7.143, with a standard deviation of 1.994. From **Fig. 12**, $\boldsymbol{C_v = \frac{1.994}{7.143} = 0.2792}$ and this indicates normal distribution of the data. With a C_v less than one, the data is consistent. This shows an adequate level of performance of the transit system through the waiting time survey. The p-value is 0.153, hence, the null hypothesis is accepted.

Travel Time

The variation in travel time for making a trip is an indicator of congestion on the route. Right of way is a major characteristic of a Bus Rapid Transit system.

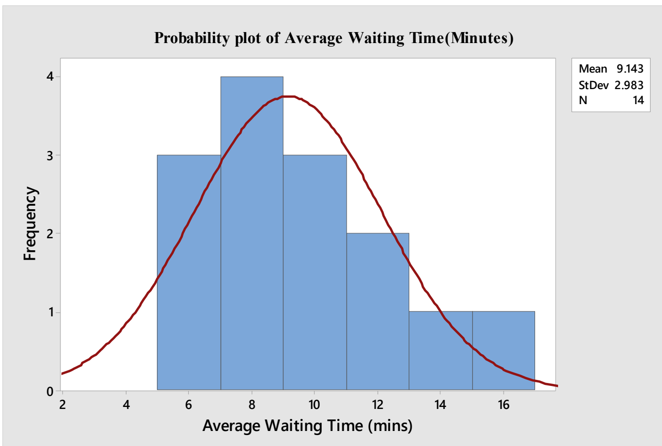

Fig. 11 Probability Distribution of the Waiting Time of Commuters (Peak).

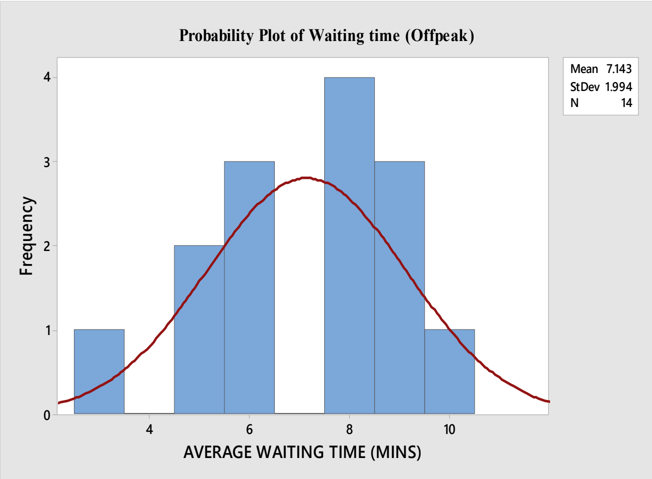

Fig. 12 Probability distribution of the waiting time of commuters (Off -Peak).

Lagos BRT presently does not have the whole route to itself as there are lane merges along the BRT corridor, consequently this has led to some variation in the travel time. This, however, has severe consequences on the scheduling of services as well as the performance of the transit system.

From the average travel time of the buses from Mile 12 to TBS and from TBS back to Mile 12. It is evident that in the morning the travel time along the southbound direction is greater than the travel time along the northbound direction, this is due to flux of passengers going to their respective workplaces which leads to traffic congestion along that direction. This is because movement in the southbound direction means moving from residential areas towards the commercial areas. In the morning however there is less or no congestion along the northbound direction.

From **Fig. 13**, the Probability distribution of the travel time of buses (Morning Peak-Southbound) has a $C_v = \frac{7.82}{55.07} = 0.1420$ with a p-value of 0.407, hence the null hypothesis is accepted. **Figure 14** shows the

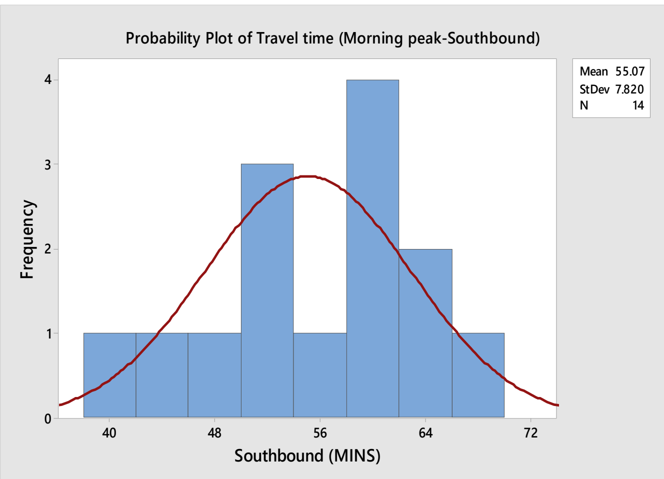

Fig. 13 Probability Distribution of the Travel Time of Buses (Morning Peak-Southbound).

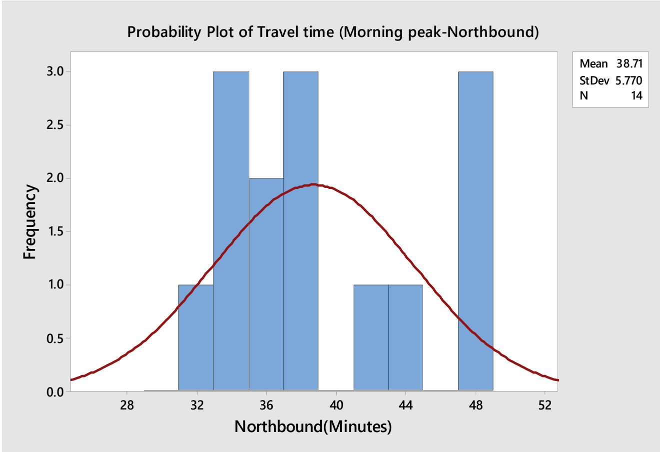

Fig. 14 Probability Distribution of the Travel Time of Buses (Morning Peak-Northbound).

Probability distribution of the travel time of buses (Morning Peak-Northbound Direction) with $C_v = \frac{5.77}{38.71} = 0.1490$ and a p-value of 0.113, hence the null hypothesis is accepted. The data is normally distributed and consistent. The travel time plot for the northbound direction during the peak period also shows consistency and low variability.

For the morning off-peak period in the southbound direction, it was observed that there is similarity between the travel times of the southbound and northbound directions. This can be due to the evenly distributed congestion between both directions. **Figure 15** shows the probability distribution of the travel time of buses (Off-peak-Southbound) with a $C_v = \frac{5.64}{41.5} = 0.1359$ and a p-value that is less than 0.05, the null hypothesis is rejected.

Figure 16 shows the probability distribution of the travel time of buses (Off-peak-Northbound) with a $C_v = \frac{4.615}{35.29} = 0.1308$ and a p-value that is less than 0.05; the null hypothesis is rejected. Both **Figs 15–16**

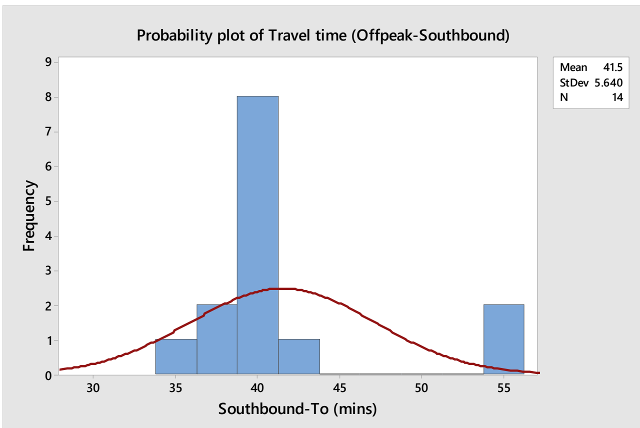

Fig. 15 Probability Distribution of the Travel Time of Buses (Off-Peak-Southbound).

have low values of coefficient of variation. This indicates low variability in the travel times for the off-peak period and it can be inferred that there is consistency in the service rendered.
The probability distribution of the travel time of buses (Evening peak-Southbound) from **Fig. 17** has a $C_v = \frac{5.204}{47} = 0.1107$ and a p-value of 0.173, hence the null hypothesis is accepted. From **Fig. 18** the $C_v = \frac{11.29}{58.14} = 0.1942$ for the evening peak-Northbound direction with a p-value of 0.094, hence the null hypothesis is accepted.

With C_v values of 0.1107 and 0.1942, for evening south and Northbound directions respectively, the data shows low variability in the travel times for the evening peak period. This shows consistency in the data collected.

A careful observation of both the morning and the evening peak shows that there is an exchange in the average travel time between the southbound and the northbound. The interpretation of this is that the congestion in traffic along the southbound direction in the morning is similar to the congestion along the northbound in the evening because most of the commuters are heading home from work during this period.

CONCLUSION

The Bus Rapid Transit in Lagos state was studied through the collection and analysis of data taking Mile 12 to TBS route as case study. Questionnaires were administered to commuters in order to analyse the demographic pattern of the transit system and operational data were collected considering boarding and alighting data, headway, arrival rate of commuters, waiting time of commuters and the travel time.

Results from the demographic analysis shows that there are more male commuters than their female counterparts, with the male gender occupying 63% of the respondents and the age group between 26 and 35 years represent the largest percentage of commuters using the transit system which is 40% of the entire respondents. From the analysis, 36% of the commuters own personal cars, this evidently shows the efficiency of the transit system towards the reduction of vehicular traffic on the roads. Boarding and alighting patterns show the bus stops with relatively high flux of commuters. From this study it was observed that bus stops such as Fadeyi, Mile 12, Ojota, Ketu, Costain, CMS and TBS were usually busy with commuters.

Probability plots were used to analyse the distribution and consistency of the data obtained through the headway, arrival rate, waiting time and travel time. All of these data followed normal distributions and had low values of coefficient of variation; this shows that the data represent real life situation with low variability in the studied system.

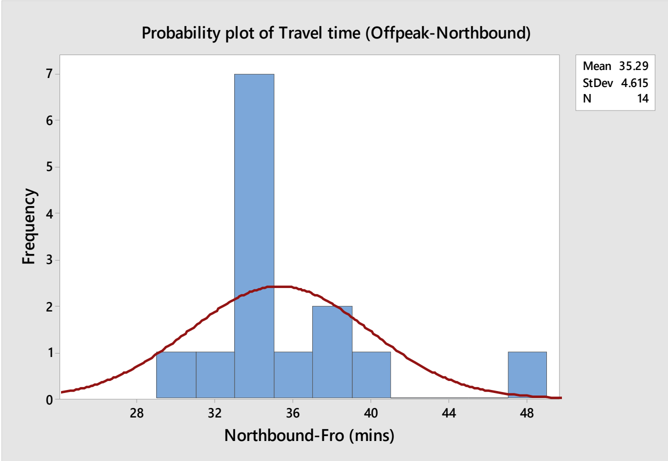

Fig. 16 Probability Distribution of the Travel Time of Buses (Off-Peak-Northbound).

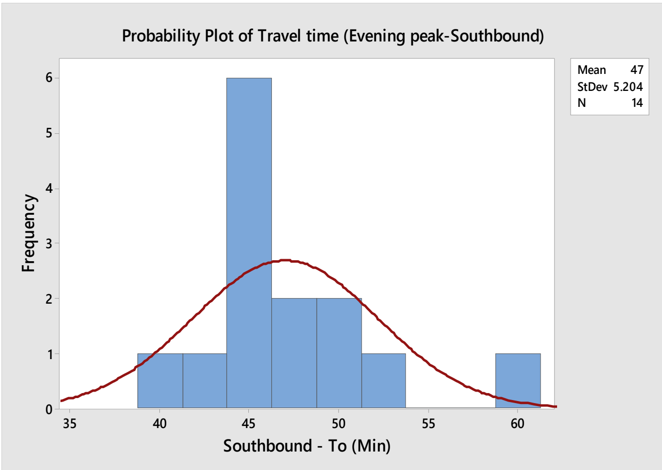

Fig. 17 Probability Distribution of the Travel Time of Buses (Evening Peak-Southbound).

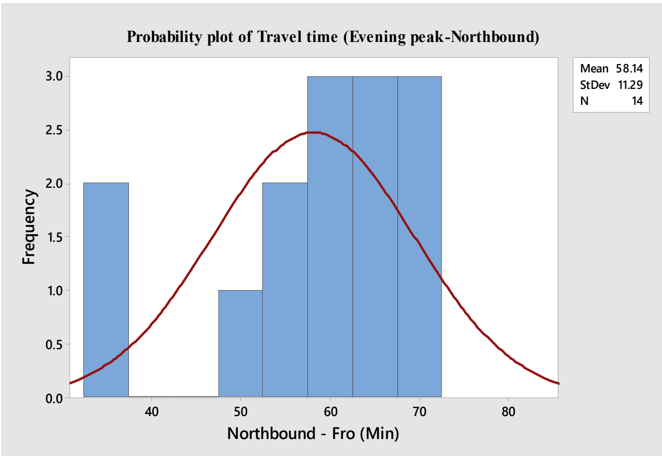

Fig. 18 Probability Distribution of the Travel Time of Buses (Evening Peak-Northbound).

REFERENCES

Abbas, O. O. (2007). Rapid urbanisation and coping strategies: The case of Lagos, Nigeria. Published Master Thesis, Department of Urban Planning and Environment, Division of Urban and Regional Studies, Kungligu Tekniska Hogskolan Institute of Technology, Stockholm, Sweden.

Adetunji, M. A. (2013). Assessment of the quality of urban transport services in Nigeria. *Academic Journal of Interdisciplinary Studies*, 2(1), 233-242.

Adewumi, E. & Allopi, D. (2014). An appropriate 'Bus Transit System'. *International Journal of Science and Technology,* 3(4), 248 – 254.

Akpomrere, O. & Nyorere, O. (2013). Bus rapid transit (BRT) and railway transport system in Lagos: geographic information system approach. *International Journal of Economic Development Research and Investment*, 4(1), 53 – 63.

Amiegbebhor, D. & Dickson, O. (2014). Impact assessment of bus rapid transit on commuters satisfaction in Lagos State Nigeria. *Journal of Research in Nation Development,* 12 (2), 198 – 208.

APTA. (2007). Public Transportation: benefits for the 21st century. American Public Transportation Association, Washington D.C.

Basorun, J. O. & Rotowa, O. O. (2012). Regional assessment of public transport operations in Nigerian cities: The case of Lagos Island. *International Journal of Developing Societies,* 1(2), 82-87.

Dodson, J., Mees, P., Stone, J. & Burke, M. (2011). The principles of public transport network planning: a review of the emerging literature with selected examples. Urban Research Program: Melbourne, Australia.

LAMATA. (2009). Lagos Brt-Lite: Africa's first bus rapid transit scheme. Lagos Metropolitan Area Transport Authority: Lagos, Nigeria.

LAMATA. (2013). BRT. Available at: http://www.lamata-ng.com/brt.php. Accessed 22 January 2016.

LAMATA. (2013). Challenges of transportation in Lagos. Lagos Metropolitan Area Transport Authority: Lagos, Nigeria.

Santhakumar, S. K. (2003). *Transportation system management for Madurai city using GIS*. Madurai Map of India Publication.

Somuyiwa, A. O. (2008). Impact of transport negative externalities in urban cities of developing economy, a psychological analysis. *Pakistan Journal of Social Science,* 5(9), 918-926.

Orekoya, T. (2010). The bus rapid transit system of Lagos State Nigeria: A presentation to United Nations forum on climate change mitigation, fuel efficiency and sustainable Urban Transport, Seoul, Korea.

WPR (World Population Review) (2015). Lagos population. Available at: http://www.worldpopulationreview.com/world-cities/lagos-population/. Accessed 25 January 2016.

Wright, A. (1999). Public transport in third world cities, Geerlings H.J, London.