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Assessment of the Effectiveness of Dar Es Salaam Bus Rapid Transit (DBRT) System in Tanzania

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Abstract

Dar es Salaam Bus Rapid Transit (DBRT) is a high quality bus based transit system that delivers fast, comfortable, and affordable cost. It does this through the provision of dedicated bus lanes and iconic stations aligned to the center of the road, off-board fare collection and regular time schedule operations. For more than fifty years, residents of Dar-es-Salaam city faced public transport problems mainly delays to work due to congestions, frequent vehicle accidents resulting into death, injury, permanent disability and loss of properties. Since 1980s the government of Tanzania struggled to eliminate the transport problems in the city with little success. The DBRT system which started its operation in 2016 has been found to be an effective solution for urban transport problems in the city. This study used questionnaires and interviews to get and analyze responses from households and commuters for the purpose of investigating effectiveness of DBRT system in the city. The study investigated that waiting time for passengers at stations/terminals is reduced to more than 50%, delays in journey is reduced to 60% and savings of fare cost to passengers is 28% compared to previous daladala mode. In order for the DBRT system to be viable life cycle cost and sustainable project there should be connections between DBRT truck roads and arterial roads but also routes to remote areas should be established. In order to serve large group of people the fare price per trip should be adjusted to 77% of the current fare price.

Keywords: Effectiveness; DBRT; BRT; DART; UDART.

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1. Introduction

BRT is relatively new mode of transport; it can be found in 195 cities around the world and is investigated to be an effective and viable solution for urban mobility challenges. Unlike more traditional bus systems, BRT operates in exclusive designated lanes, and often has greater capacity, a unique ticketing system and provide real-time information [1].

The first modern BRT system in the world was the Rede Integrada de Transporte (RIT, "Integrated Transportation Network"), implemented in Curitiba, Brazil in 1974 [1]. Most of the elements that have become associated with BRT were innovations first suggested by Curitiba Mayor Architect Jaime Lerner. Initially just dedicated bus lanes in the center of major arterial roads, in 1980 the Curitiba system added a feeder bus network and inter-zone connections, and in 1992 introduced off-board fare collection, enclosed stations, and platform-level boarding. Other systems made further innovations, including platooning in Porto Alegre, and passing lanes and express service in São Paulo [2].

In Tanzania the construction of BRT System in Dar es Salaam city started in 2012 for the purpose of reducing traffic delays, congestion and frequency traffic accidents [3]. Reports show that as for 2014 commuter buses operated in Dar es Salaam city were 5,200. Despite the big number of buses, motorcycle and tricycles in the city but traffic problems remain high. The routes had tremendous traffic accidents, waiting time for daladala at stops were more than 1hour, delays on journey due to traffic congestion were also high [4, 5]. Thereby the introduction of BRT System by government of United Republic of Tanzania (URT) was found to be practical solution to solve traffic problems in Dar es Salaam city [6].

Table 1.1: BRT phase construction in Dar es Salaam city [7].

DBRT Phases	DBRT Road Corridor	Length (Km)
Phase 1	Morogoro -Kawawa North- Msimbazi-Kivukoni	20.9
Phase 2	Kilwa-Kawawa South	19.3
Phase 3	Uhuru Street-Nyerere-Bibititi-Azikiwe Street	23.6
Phase 4	Bagamoyo-Sam Nujoma	16.1
Phase 5	Mandela Road	22.8
Phase 6	Bagamoyo Road	27.6

The DBRT system in the city comprises of six phases and the construction of phase one is completed in December 2015 with a total cost of €134 million funded by the African Development Bank, World Bank and Government of Tanzania [7]. DBRT phase 1 began fully operations on May 2016 covering 20.9 km. The total distance for the whole project is 130.3 kilometers and it is expected to save 90% of the commuters living in Dar es Salaam city to which after completion will increase productivity of the workers by reducing substantially time spent in traffic jams [7].

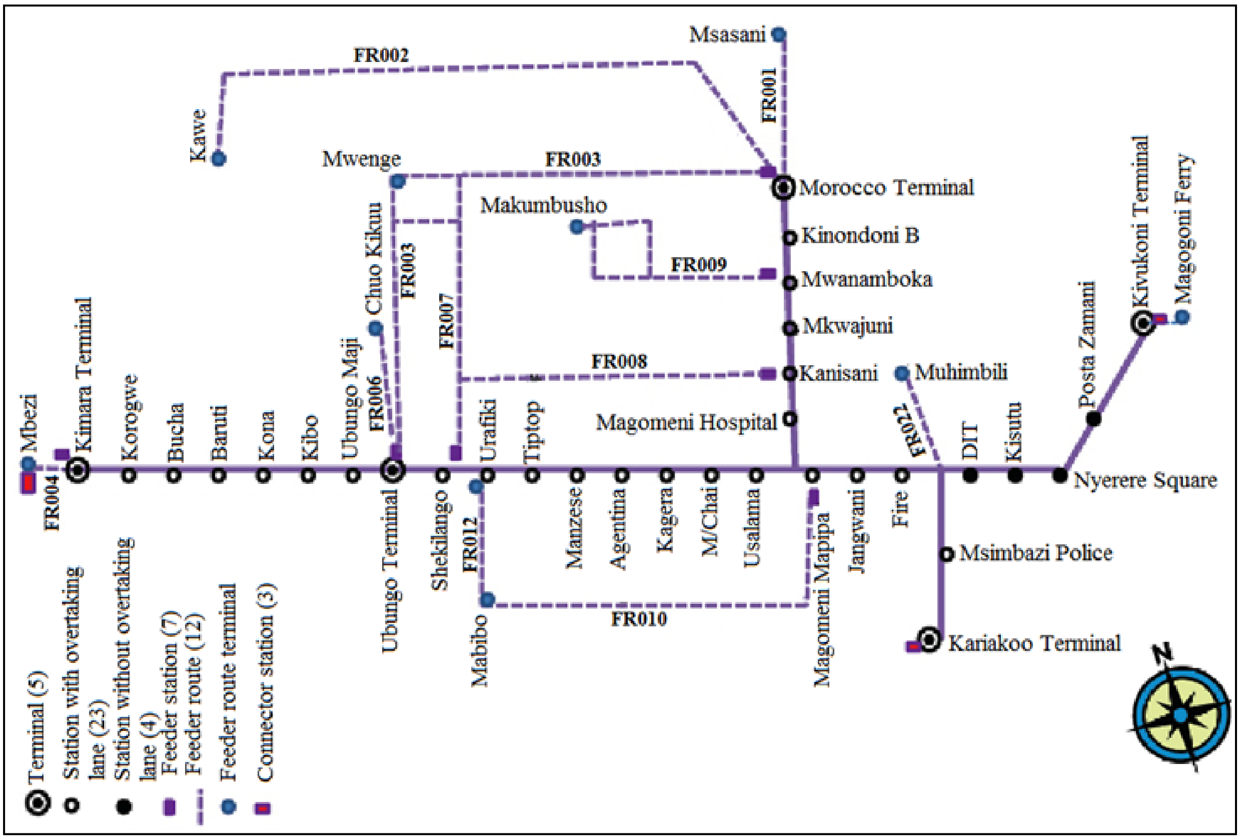


Figure 1.1: Map for phase 1 DBRT network [8]

The DBRT is operated by UDART (Usafiri Dar es Salaam Rapid Transit) under the surveillance of the SUMATRA (Surface and marine Transport regulatory authority). Since April 2015 the Dar Rapid Transit Agency (DART) signed a contract with UDART a special formed company to provide interim services of the DBRT system which are to provide training to future operators and build up local capacity.

Currently the DBRT corridor is serviced by 140 golden dragon buses, providing express and local service from 0500 to 2300 hours daily [9]. Table 1.1 gives the corridors and length of truck roads for each phase forming the DBRT network when completed. The phase 1 corridor consists of 20.9 km of trunk road, 57.9 km of feeder roads, 5 main terminals and 27 stations; the route is designed to carry more than 300,000 commuters daily [8]. Figure 1.1 gives the phase 1 road network which includes trunk and feeder roads, stations and terminals.

1.1 Basic Design Guidelines of the DBRT System

Standard cross sections for phase one DBRT trunk road project have been established. The road consist of dual carriage way each direction for mixed traffic and two lanes (l x l) for rapid buses at the center of the road.

The width of mixed traffic lanes is 3.0 m and that of rapid buses is 3.3 m. On some locations the sidewalk and bicycle lanes have been provided in both directions. The width of side walk is 2.5 m and for bicycle is 1.5m [7]. At bus terminal and stations, a 5.0 m wide station and one additional lane each side for buses overtaking including 0.3 m wide median is provided [7].

2. Effectiveness of DBRT system

It is a measure of how successful a BRT system performs the desired objectives. The parameters used to measure effectiveness of BRT system are travel cost saving, travel time saving, reliability, accessibility, accident rate, commuter comfortability and social-economic uplift. Other parameters which can be included to measure effectiveness of BRT systems are condition of the BRT infrastructures (road way, stations and terminals) and condition of buses, environmental pollutions, skills and experiences of drivers and speeds.

The BRT effectiveness parameters when properly controlled the system can be competitive and sustainable. Other researchers has suggested the following parameters for measuring effectiveness of BRT system which are trip travel time, average trip speed, bus delays, maximum speed, average schedule deviations, average dwell time, travel cost, improving retained income and standard deviation of dwell times [10, 11, 12]. For this study travel cost saving, travel time saving, reliability, accessibility, accident rate, commuter comfortability and social-economic uplift have been analyzed for DBRT system.

a. Traffic accidents

Vehicle road crashes causes death of life, injuries, disabilities, loss of properties and an increase of dependants especially in developing countries. The demand of effective transportation system which will minimize traffic crashes and environment pollution is the requirement of many cities in the world. Urban transportation is the fourth leading sector with high number of death of life caused by traffic accidents in the world, particularly in Asia and Sub-Saharan Africa [13, 14, 15]. Fatalities caused by traffic crashes in Dar es Salaam city for the year 2016 was 325 lives an increase of 2.8% compared to the year 2015 [16].

Reports indicated that, the introduction of BRT system has reduced road accidents, environmental pollution and traffic congestion for more than 50% in many cities in the world [17, 18, 19, 20].

The introduction of BRT in Bogota city during the year 2004 reduced accident crashes by 92%, reduced travel time by 32%, reduced vehicle emission by 40% and fuel savings of 47% [21]. In Guadalajara, the average monthly crashes on the BRT corridor decreased by 46% during the first year of operation [22].

Therefore BRT system has proved its effectiveness in reducing traffic accidents in many congested cities and this is mainly because the buses use exclusive lanes from mixed traffics. However, the use of exclusive road infrastructure also results into reduced travel time, reduced travel related cost and enhance comfortability which creates mode shift from private cars and other urban transport modes to BRT system.

b. Cost effectiveness

The major advantage of BRT system over other urban public transit is its cost-effectiveness. The investment cost of building BRT system and its operating cost is less than light rail and Metro transit systems [23, 24, 25]. However, rail and metro transit system require electric as best alternative energy to run the engines compared to diesel engines. However for developing countries, electric energy is a challenge because it is not sustainable.

The high investment and operation cost of metros makes them less economically viable in medium-sized developing cities than in megacities which make them less affordable public transport [23]. For USA alone the operating costs per hour for light rails is twice more than rapid transit buses [26] and investment cost to build a mile length of bus way was around 60% less than a typical light rail system provided similar average operating speed of the two systems [27].

Although, other researchers argued that, operating cost of BRT system is higher than light rail system which encourages investors to invest on light rail system for public urban transport [26]. The operating cost of BRT system is considered high because it require many buses and operators to accommodate the same amount of commuters per trip on which there will be future offset of high investment cost for light rail transit especially in Mega cities. Generally the public BRT system is a right choice for urban transit particularly for developing countries as it is effective life cycle cost project.

c. Reliability

Service reliability is the ability of transit operators to provide a consistent level of service and maintain operations as scheduled. Customers may consider service unreliable when bus arrival times are not as scheduled or when travel times are highly variable and unpredictable [28, 29]. Having reliable service improves customer satisfaction and the perception of high-quality service, which may consequently increase ridership for the transit operator.

For the case of DBRT, the buses are scheduled to leave stations and terminals at every 15minutes interval. Schedule adherence refers to the ability of a transit service to stay on schedule at designated time points usually within 0 to +5 minutes of the schedule [29].

DBRT features such as dedicated running ways, iconic stations, off board ticketing, scheduled arrival and departure time and proper information using mobile apps and displays help improving schedule adherence by reducing variability in waiting and in-vehicle travel time.

Schedule adherence is used to measure deviations of arrival time at station from scheduled time. However, occasionally late arrival at station due to traffic accidents and service disruptions are not considered unreliability.

A study conducted in Changzhou located at the southern Jiangsu province of China indicated that the service reliability of BRT is different from morning and evening time. The bus operators suggested that unreliability were caused by headway irregularity which is worst during the A.M and P.M peaks. However, from the perspective of passengers the un-liability was based on potential waiting time (PWT) and reliability buffer time (RBT), service reliability is the worst during the early period followed by the AM Peak [30].

d. Travel cost saving

Affordability is acknowledged as a key constraint to mobility among the urban low income people, many of whom spend 20 to 30% of their household income on travel [31]. It is often argued that, by improving effectiveness, BRT systems could bring public transport operating costs down and thus offer more affordable fares to users [32]. There is indeed evidence of lower fares offered by BRT travel services, for example in Jakarta, it is reported that about half of users saved money when using Transjakarta [32].

In Lagos, the BRT travel fares were formalized which brought about travel cost savings to many passengers compared to the former unregulated urban transport system on which the travel fares were subject to hour-by-hour variation, which resulted into fare reduction by 30%, in journey time by 40% and reduction of waiting time by 35% [33].

Hidalgo and Yepes [34] reported that total daily savings for passengers who would have paid two fares on the traditional system were in the order of 8% - 12% of the average daily income of low income households in Bogotá. However not all potential poor passengers benefit in this way. When compared to a single fare trip it is cheaper for the traditional bus system than BRT system because BRT use a formalized trip fare which is higher for commuters taking single traditional bus directly to their destination [25].

e. Travel time saving

Travel time saving is a significant benefit to the low income people given that they typically face very long travel times due to a combination of poor location and limited access to high-speed modes. There is evidence that BRT systems have the capacity to significantly reduce average passenger travel times through its combination of exclusive infrastructure and speed-enhancing technology [35]. But also its accessibility due the connection with arterial, feeder and access roads make its time saving to commuters much significant.

However, it is very important to assess travel time by user since related costs accrued due to travel delays are significant. Hidalgo and Yepes [34] conducted study on travel time savings for Bogotá's TransMilenio Phase 1, and found that higher travel time savings is for poor people which was 18 minutes per trip than for middle income users of 10 minutes per trip. Tiwari and Jain [36] compared travel time savings on the Delhi BRT by mode, and found that cyclists save more time than bus users in the order of 33%. Although they did not focus specifically on income levels, they point out that in Delhi low income households are predominant users of Non-Motorized Transports.

f. Passenger comfort

This is a psychological state characterized by stress and lack of control due to the suffocation caused by overcrowding before and during trip including poor physical facilities of the BRT system [37]. This is considered in terms of noise levels produced by bus and passengers, vehicle bumping due to poor road condition, overcrowding of commuters at the stations and terminals and within the buses, rough driving and over speeding, poor/lack of toilets at the terminals, bad communication between ticketing agency or drivers and commuters, poor hygiene and ventilation in buses and stations and lack/poor travel information. Comfort is one of the major travelling behaviors which cause commuters to shift to other modes neglecting other benefits such as travel time and fare. In order to minimize overcrowding and improve comfort to commuters it is necessary to shorten waiting time of buses at station and applying the bus platoon system.

For the case of DBRT, there is overcrowding in buses especially during peak hours in the morning from 06:00 to 08:00 and in the evening from 16:00 to 19:00.

The survey conducted for Lagos rapid bus transit, 63% of the surveyed commuters were satisfied with the level of comfort provided by the BRT system which was mainly because of new buses which were providing services [38]. According to study conducted by DCC [39], 47% of respondents suggested that daladala service is less comfortable than the level of service provided by car. This was primarily due to inconvenient service by daladala including long waiting hours at the bus stop and unreliable service. The study also found that 92% of the respondents suggested shifting from car and daladala to DBRT once introduced [39].

Uncomfortability is generally experienced for old and subserviced BRT infrastructures and buses mainly being slippery and hardly accessible seats, inconvenient handles, inconvenient turnstiles, lack of maintenance, difficulty to board and get off, lack of in-vehicle route information and carelessly driving [37].

3. Investigation procedure

The major data collection method adopted by this study was a designed questionnaire and interviews to households living nearby DBRT terminals and commuters using DBRT buses. The questionnaire was designed depending on the need for research findings which is to assess the effectiveness of BRT system in Dar-e-salaam city. The questions were of three types, which included closed questions, the “yes” and “no” answers and the open ended questions to which a participant gave his or her thoughts on a particular question.

a. Research instrument and sampling technique

Random sampling was adopted in order to identify potential respondents who are currently benefiting with the presence of BRT system in Dar-es-salaam city. The sample covered all people who benefit directly or indirectly by the presence of BRT system in Dar-es-salaam.

b. Research design process

A sample of 200 questionnaires was supplied to the households living nearby DBRT terminals and commuters. For the case of commuters, the samples were picked at every terminal. The DBRT system has five major terminals, on which 10 questionnaires were supplied and filled by passengers while in each terminal and 10 questionnaires were supplied and filled by passenger while in bus. 20 questionnaires were supplied to the selected households surrounding that particular terminal. The respondents were randomly selected and out of 200 questionnaires supplied the returned questionnaires were 98%.

4. Results and discussion

The analysis of the data for this study was based on the selected effectiveness parameters. The selected parameters are comfort to passengers, time and fare costs savings, accessibility of DBRT stations/terminals, and adherence of DBRT buses with travel schedule, traffic accidents and economic uplift to households. The following are the results and discussion of the data collected for each selected parameter.

a. Comfortability to passengers

The results on data of comfortability provided by the DBRT buses to commuters indicated that 56% of the respondents are very much satisfied with the comfortability of DBRT compared to previous daladala. During peak hours the passengers per single trip in daladala were more than two times their capacities. However 72% of the respondents are satisfied with the general environment at terminals and stations. Apart from quality of runways, buses, travelling characteristics and quality stations/terminals but also 63% of the respondents were satisfied with general DBRT operation in providing safe, accessible and affordable transport services.

The investigation also indicated that 52% of the respondents are not satisfied with the general services provided by ticketing agency (MAXCOM). This is because during peak hours there are queuing of commuters at stations and terminals due to few attendants causing delays in stations/terminals. The suggestions to eliminate delays due ticketing challenges are that DART should provide electronic travel cards (Dartcard) which should be linked with mobile payment apps. A passenger can load money to the Dartcard through mobile phone payments. But also the MAXCOM can increase number of attendants at stations/terminals to serve boarding tickets to passengers.

However the commuters suggested that stakeholders of DBRT system are not very well informed on the rules and regulations regarding DBRT operations. The results showed that 69% of the respondents are unaware of the rules, regulation and operation guidelines of the DBRT which violet important regulations such as pedestrians walking along the DBRT driveway and crossing on unmarked areas and other vehicles and motorcycles to share the DBRT lanes which may cause accidents and interruption of flows and delays. The respondents suggested that the regulations, rules and guidelines can be advertised through radios, TVs, newspapers, website, exhibition and displays in buses.

b. Accessibility of DBRT buses

The network of DBRT system is not complete, on which some of the remote areas are not connected to the DBRT corridor through access and arterial roods. Phase 1 DBRT system is complete only for truck road and connected to some nearby feeder roads. The accessibility to DBRT stations/terminals is mainly through other modes particularly daladala (figure 4.4) especially when the passengers lives in far remote areas. The respondents when asked about whether the DBRT stations/terminals are easily accessible, only 48% agreed (figure 4.3 right) which indicates a need for immediate connections between DBRT truck roads and minor roads and to create routes to remote areas. However majority of the passengers spent up 20 minutes to walk to the DBRT stations/terminals (figure 4.3 left) this is because most of the DBRT stations/terminals are not aligned with stops, stands and stations of other modes.

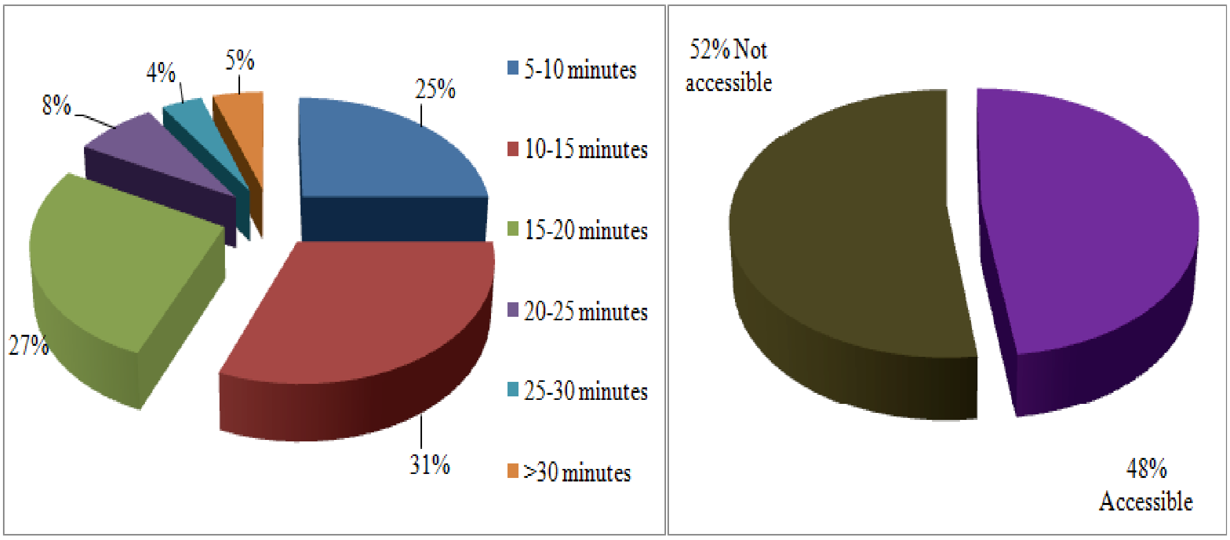


Figure 4.3: Time spent to arrive (left) and accessibility level (right) by respondents to access DBRT stations/terminals

Different modes are used by passengers to arrive to a stops and stands nearby DBRT stations and terminals. The investigation on modes used by DBRT passengers to access DBRT stations/terminals, 43% of the respondents suggested using daladala, these passengers are mainly those coming from remote areas (figure 4.4). 22% of the respondents suggested using bodaboda (motorcycles) regardless of high cost than daladala, the passengers prefer using it due to time saving but also a passenger can be dropped at DBRT station/terminal without additional time for walking. 25% of the respondents suggested walking from original point to DBRT stations/terminals and these are those coming nearby stations/terminals.

Therefore in order for the passenger to minimize time and money spent to access DBRT services, there is important to introduce routes to remote areas but also for the next DBRT phases the aligning of DBRT stations/terminals with other public modes should be considered in implementation plan.

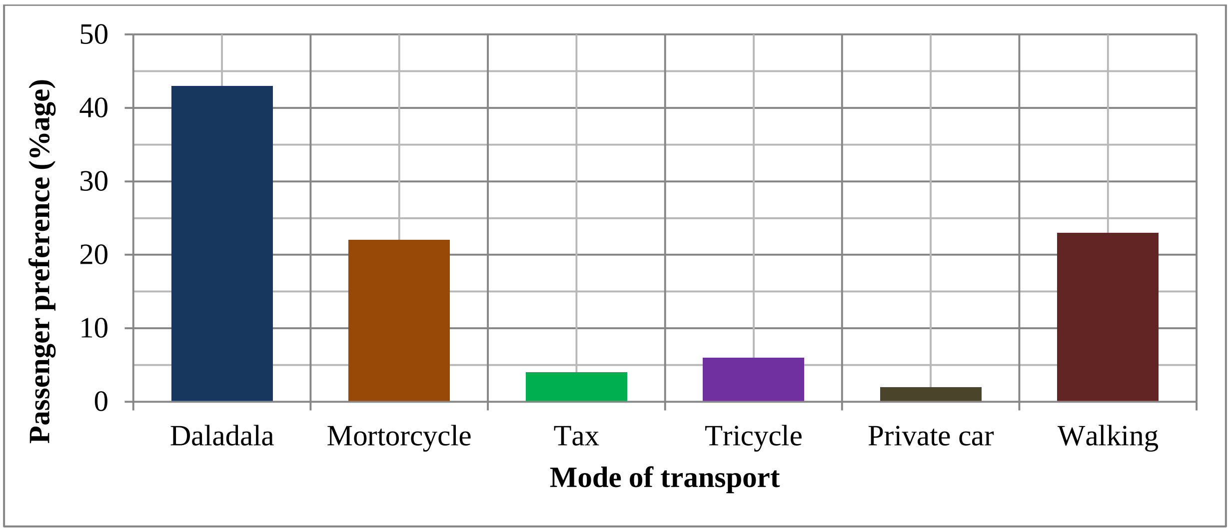
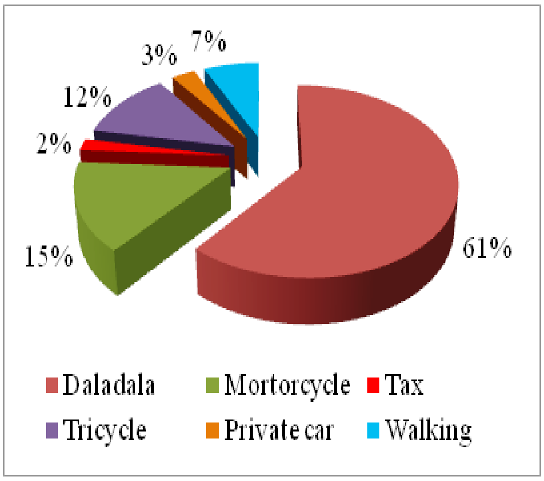


Figure 4.4: Mode of transport used by commuters before arriving to the DBRT terminals and stations

c. Reliability and market shares of transport modes

The study conducted to investigate reliability of DBRT system indicated that 82% of the respondents agreed that there is adherence with travel schedule except for off peak hours where there is increase of arrival time of buses at stations/terminals from 15minutes to 25minutes. The reliability of buses resulted into mode shift from previous daladala to DBRT. The survey on type of modes used by passengers to CBDs and city centers before and during DBRT operation, the results indicated that 61% of passengers to and from city centre were previously in the daladala, and small numbers in other modes (Figure 4.5 left). The market share of urban transport in the city was dominated by daladala. After introduction of DBRT in the city, 52% (figure 4.5 right) of the respondents suggested using DBRT service to CBDs for their daily journey to work and businesses.



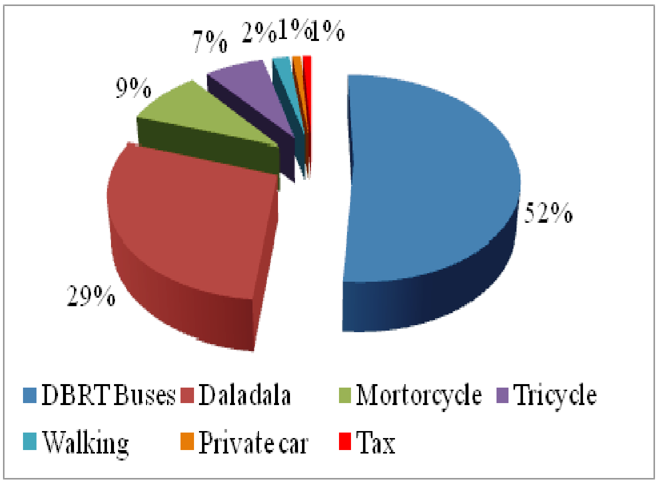


Figure 4.5: Previous (left) and current (right) mode preference by commuters in Dar es Salaam

This indicates that DBRT is competitive with daladala as indeed it is designed for such purpose. The market share by DBRT can be even high when will be complete connections between truck roads and minor roads. But also DBRT seems to offer an attractive alternative to some other public transport users and even who walked to their destinations before DBRT.

d. Cost saving for passengers

The fare for one DBRT trip is Tshs 650 set by SUMATRA on which 72% of respondents disagreed on the fare price. About 67% of the respondents benefiting the presence of DBRT operation in Dar-es-salaam suggested the fare price of Tshs 500 which can enable low and medium income people to use the system, furthermore 55% of respondents said that the only reason that make them choose DBRT system is because of time saving, security from theft and comfortability and not because it is cheaper compared to daladala particularly those living nearby CBDs and City center.

For the passengers from Kimara to Kivukoni and Kariakoo terminals they save money by using DBRT system. The cost of daladala is Tshs 550 for one route and Tshs 450 for each bus stop. For people from Kimara working to CBDs needs to board two daladala with total of Tshs 900 which is Kimara to Ubungo and Ubungo to CBDs while for DBRT is Tshs 650 from Kimara to CBDs with a saving of 28%. However for the people living nearby CBDs there is no cost saving because by using daladala they pay Tsh 450 while DBRT is Tsh 650 per trip with a loss of 31%

For the low income commuters identified as pupils, students, machingas, mama lishe and security guards for the purpose of this research, only 51% of the respondents agreed to use DBRT for their travel. The amount is small which is mainly due to fare price of Tshs 650 for one direction. The suggestion from the respondents is that the fare price should be grouped based on the passenger categories which are adults, elders and disabled and pupils/students as Tshs 500 for adults, Tshs 300 for elder/disabled and Tshs 200 for pupils/students. DART officials agreed that the fare price should be categorized, although for the time being it is difficult to identify and control the passengers, but also fare prices for public transports are controlled by SUMATRA a separate authority.

e. Time effectiveness

About 97% of the respondents on the study of the extent of time reduced by the DBRT system clearly admitted that the presence of DBRT system has greatly reduced travelling time compared to the previous daladala and other urban transport mode. For example an average of 60 to 80 minutes was used with daladala from Ubungo to Kivukoni terminals, however with DBRT only 39 minutes with ±3 minutes excess time in journey.

Table 4.1: Excess travel time and distances from terminals for BRT phase 1 corridor.

INTERVAL	From / To	KIVUKONI	MORROCO	UBUNGO	KIMARA	KARIAKOO
Length (km)		0	9.4	11	15.4	3.3
Travel time(min)	KIVUKONI	0	30	39	48	14
Excess time (min)		0	-3	-3	+1	-3
Length (km)		9.4	0	8.7	14.3	6.9
Travel time(min)	MORROCO	30	0	25	36	24
Excess time (min)		-3	0	-4	+4	+2
Length (km)		11	8.7	0	5.2	8.8
Travel time(min)	UBUNGO	39	25	0	11	35
Excess time (min)		-3	-4	0	+2	-4
Length (km)		15.4	14.3	5.2	0	14
Travel time(min)	KIMARA	48	36	11	0	45
Excess time (min)		+1	+4	+2	0	+2
Length (km)		3.3	6.9	8.8	14	0
Travel time(min)	KARIAKOO	15	24	35	45	0
Excess time (min)		-3	+2	-4	+2	0

Table 4.1 shows travel times, excess travel time and distances from terminal to terminal for phase 1 DBRT corridor. The indicated travel time from each terminal (table 4.1) includes stopping time at intermediate stations/terminals and delays at intersections and pedestrians crossings. The maximum excess time from terminal to terminal is ±4 which indicates that the bus operators adhere to the travel schedules. The waiting time at daladala stops during peak hours was more than 1hour and for the DBRT is 15 minutes interval.

Longer travel time and waiting time for daladala was because of high traffic congestion in the city roads [4. 5]. Short waiting time for DBRT is because they use exclusive runway, the systematic delay occurs only at intersections and boarding time at terminals/stations.

Although there is reduction of travel time on the DBRT route, but there are delays at stations/terminal due to long waiting time during off peak hours from 1200 to 1500 hours and during weekends. When the respondents asked about scheduled interval of 15 minutes for the buses to arrive at the stations/terminals, 69% agreed that the waiting time of 15 minutes at stations and terminals is reasonable and 31% argued that the time should be reduced to 10minutes or platoon system should be adopted especially during peak hours. There are discrepancies in adherence to the travelling schedule during off peak hours, the buses does not arrive at stations/terminals as per indicated time plan.

When respondents asked to rank the possible factors contributing to delays of bus arrival at stations/terminals, a total of 85% pointed out that there are few passengers at stations during off-peak hours and headways at intersections (figure 4.6). When operator (UDART) asked about schedule adherence during off peak hours they admitted that it is not cost effective to operate buses for 3 hours from 1200 to 1500 hours with very few passengers and empty buses. Currently the bus arrival schedule at stations/terminals during off peak hours is extended to 25minutes interval but it is not officially indicated on the time table. In order to minimize confusion to passengers it is important to indicate the exactly schedule during off peak hours and weekends.

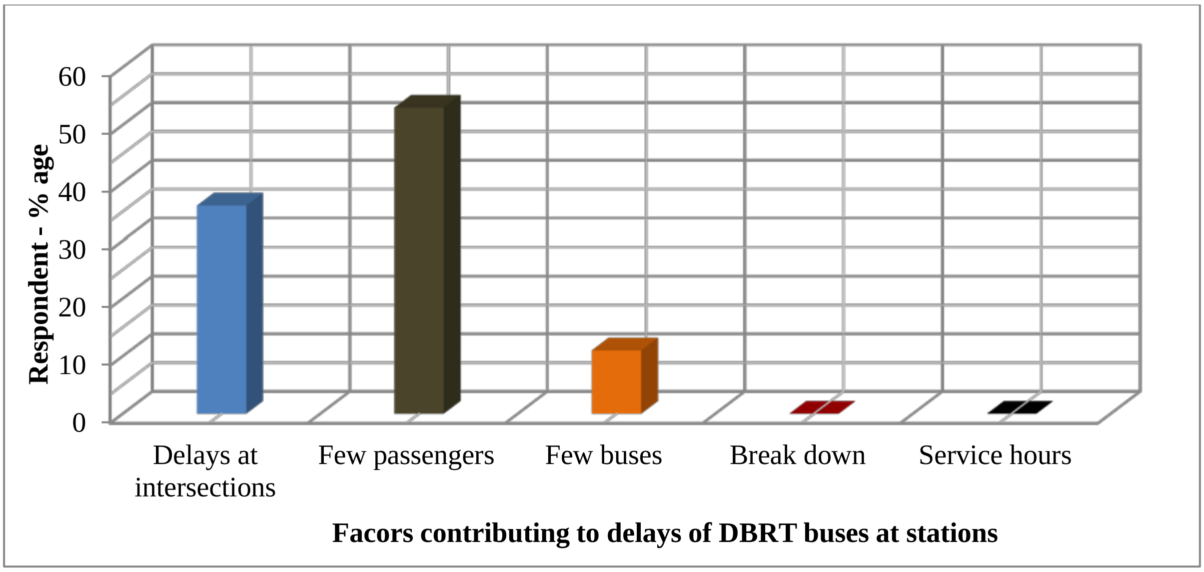


Figure 4.6: Causes of delays for BRT buses to arrive at stations during off peak hours

f. Road traffic accidents and vehicle crushes

The most vulnerable road users are pedestrians, cyclists and podaboda (motorcycles). In the year 2015 and 2016 total road accidents caused by bodaboda alone in Dar es Salaam city were 1222 which constituted 13% of traffic accident (table 4.2) on which fatalities were 8% and injuries were 88% [40].

This is because most of the bodaboda driver violets traffic regulation and rules. The fines collected due to violation of traffic regulation by bodaboda in the Country were Tshs 2,163,120,000 during the year 2016 and Tshs 1,520,550,000 in the year 2015 [16].

In Tanzania it was estimated that the loss in GDP due to traffic accidents is 3.4 % in the year 2013, 3.1% in the years 2014 and 2.8% in the year 2015 [41].

Due to high and frequency traffic accidents caused by reckless bodaboda and daladala drivers, the commuters feel secured when using DBRT. This is because the DBRT use separate lanes and therefore little collision with other vehicles but also the speed is moderate to cause accidents. Table 4.2 shows traffic accident data records in Dar es Salaam city from 2012 to 2016.

The data indicates reduction of total accidents from year 2012 to 2015 and abrupt increase in the year 2016 the base year for DBRT phase 1 operation. This may be contributed by interaction of DBRT buses with other modes on the DBRT runway because most of the road users are unawareness of DBRT operation rules and regulation.

Table 4.2: Vehicle road accidents records in Dar es Salaam from the year 2012 to 2017.

Year	**2012**	**2013**	**2014**	**2015**	**2016**
Total accidents	4134	3959	2174	3574	5719
Injured	7643	2555	2016	2169	2535
Fatality	570	167	160	293	312
References	[4]	[4]	[42]	[43]	[40]

When the respondents asked on the traffic modes contribution to the occurrence of traffic accidents, bodaboda got the highest (44%) followed by daladala (30%) (table 4.3). For the case of bodaboda the reason is due to small dimensions which allow to path through a narrow space and between vehicles on which visibility is limited by both, bodaboda driver and upcoming or crossing vehicles.

This results into accidents between bodaboda and other vihicles or between adjacent and opposing vehicles in motion during negotiation. For the case of daladala the reason is hurry of picking up the passengers at stops. The reckless daladala drivers overtakes and crosses with high speeds at unauthorized areas, but also sudden stop while they are in queues whenever they see passengers even at places with no sign of bus stop.

Table 4.3: Public modes contribution to road accidents along DBRT corridor

Public modes	DBRT	Daladala	Bodaboda	Bajaji	Tax	Pedestrians
%age accidents contribution	1	30	44	8	11	6

During the first months of DBRT operation there were tremendous number of accidents reported which involved DBRT buses and private cars, daladala, motorcycles and tricycles [9]. When respondents asked to indicate the factors contributing to traffic accidents along DBRT corridor, the highest factor ranked is Jay-pedestrians (30%) followed by Jay-drivers particularly motorcycles (25%) (figure 4.7). Generally this is because the system is new, on which the drivers and pedestrians are not aware with regulations and rules governing DBRT operation. However other researchers suggested that the reasons for such accidents are lack of formal driving knowledge and skills to DBRT drivers, insufficient turning radius and insufficient time of resting for DBRT drivers [9]. In order to improve traffic safety along the BRT corridor, education should be provided to all road users, enforcing and implementing bylaws putting more effort on information through Tv, radios, magazines and newspapers.

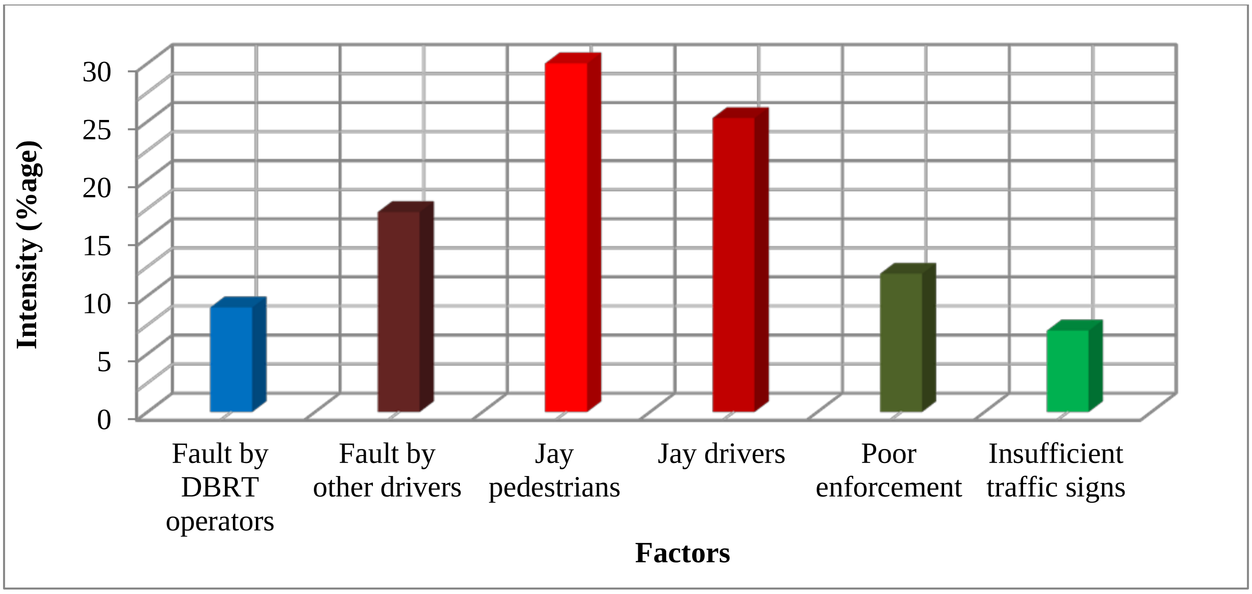


Figure 4.7: Factors contributing to traffic accidents along DBRT corridor – Phase 1

g. Economic uplift to the households

The introduction of DBRT system in Dar es Salaam city has developed new employments to the residents. In the beginning of DBRT operation the system employed more than 962 workers by DART and UDART including 300 drivers, more than 150 workers employed by ticketing agency (MAXCOM). But also number of workers has been employed by cleaning and security companies working in DBRT stations and terminals. The number of employment is increasing as the system is not operating at peak demand. The employments have increased per capita income of households living in Dar es Salaam city [44].

For the case of passengers using DBRT they save 28% of transport money to and from working areas (see section 4.4) but also they maximize working time because there are no delays at stations/terminals and in journey caused by congestion, accidents and break downs by daladala and other vehicles. The investigation revealed that 60% of the respondents suggested that their household income increased to the range of 0 – 5.0% and 28% of the respondents has increased their household income to the range of 5 – 10.0% (figure 4.8).

Furthermore, other services which have been improved along DBRT corridor phase 1, includes car parking area constructed at Kimara mwisho, renting house business, food and drinks services nearby and adjacent DBRT stations and terminals, advertising business through displays on DBRT buses and terminals/stations.

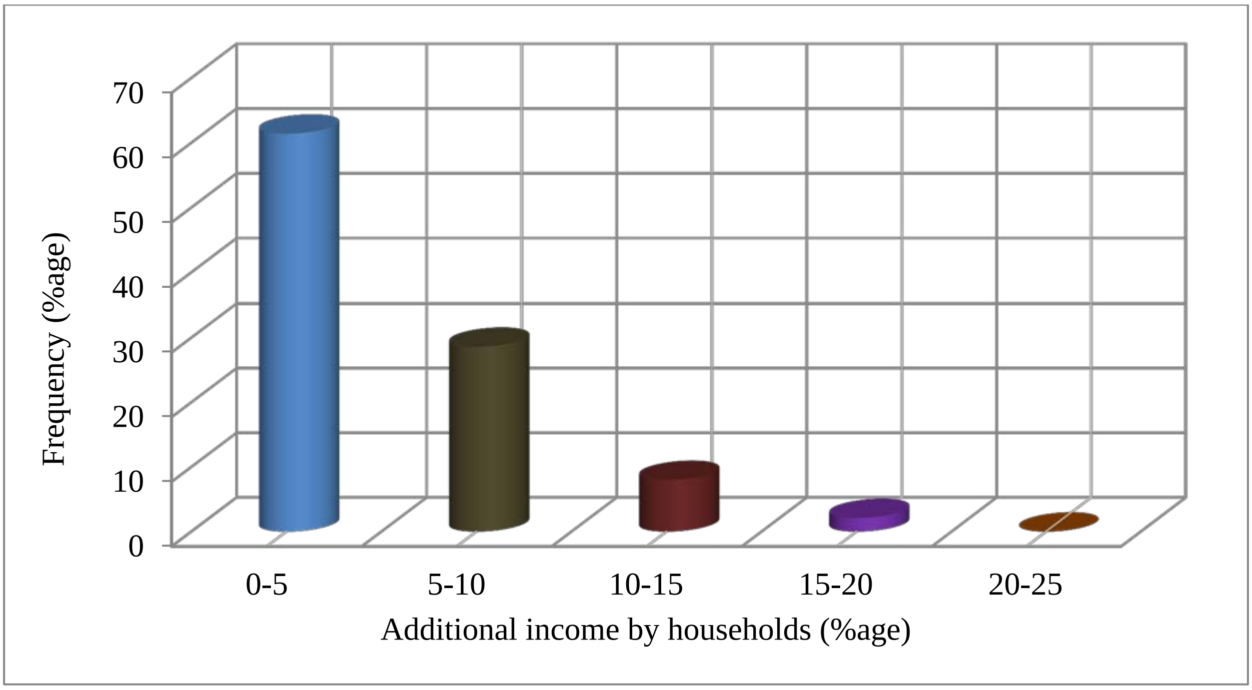


Figure 4.8: Economic contributions of BRT system to households along the BRT corridor

The effectiveness of the BRT system is reduced whenever the service provided is poor which is contributed by deterioration of BRT infrastructure such as runways, terminals/stations and buses, poor information system and ticketing services. It is important to conduct regular evaluation of performance of BRT system for short term and long term intervals. The effectiveness of BRT system can be measured using equation 1.

$$E_f = \sum_{i=1}^{N}\left(\frac{F_{PE}}{N}\right) \quad (1)$$

Where: Ef – effectiveness factor (Ef ≤ 1)

FPE – factors for parameters affecting BRT performance; N – number of parameters

The parameter can vary from place to place and time to time depending with the responsible agency operating the BRT and challenges facing the system.

For general BRT systems, the following are the factors for measuring the effectiveness.

Fac = (1-rac): factor for traffic accident and $r_{ac} = \frac{\text{Accidents involved BRT buses}}{\text{Total accidents along BRT corridor}}$

Fco = (1-rco): factor for travelling cost and $r_{co} = \frac{\text{Cost of BRT buses per trip}}{\text{Average cost of competitive modes}}$

Fti = (1-rti): factor for time delays and $r_{ti} = \frac{\text{Average delays of the system}}{\text{Average travel time of the system}}$

Fas = (1-ras): factor for accessibility and $r_{as} = \frac{\text{Average daily time spent by passengers to access stations/terminals}}{\text{Maximum average daily recommended time}}$

Fcf = (1-rcm): factor for comfortability and $r_{cm} = \frac{\text{Percentage average daily passenger discomfort perception}}{\text{Hundrend percent passenger discomfortability}}$

Fre = (1-rre): factor for reliability and $r_{re} = \frac{\text{Average daily number of missing arrivals per schedule}}{\text{Average daily number of arrivals}}$

Table 4.4: Rank for particular BRT effectiveness range

Effectiveness	**0.40 < E_f**	**0.40 ≤ E_f < 0.55**	**0.55 ≤ E_f < 0.70**	**0.70 ≤ E_f < 0.85**	**0.85 ≤ E_f ≤ 1.00**
Rank	Poor	Fair	Good	Very good	Excellent

The effectiveness factor can be used to predict BRT market share and sustainability of the project.

However the contribution of individual factor to the effectiveness of BRT system differs and therefore it is important to investigate the weight of each factor to be incorporated into equation 1. For DBRT system the next study is to investigate the weight factors contribution to effectiveness of DBRT for sustainable economy.

5. Conclusion and recommendation

The introductions of BRT system in cities have been investigated to be viable life cycle cost project especially when properly managed. The best performance of BRT system is managed against effectiveness parameters.

The results from data analysis indicated that the DBRT system is effective mode of mass transit in Dar es Salaam city. Delays in journey have been reduced to about 50% in average, but also fare price is less that 28% from previous daladala mode. With regards to comfortability, 56% of the respondents are very much satisfied, but also 82% of the respondents suggested that the DBRT buses are reliable.

However the study investigated that 52% of the respondents takes long time to access the DBRT stations/terminals but also long time for ticketing time due to few ticketing attendants is experienced by passengers at stations/terminals. In order to reduce waiting time and overcrowding at stations/terminals due to delay on ticketing process by MAXCOM, the DART agency should provide Dartcards to passengers at a reasonable cost which are to be connected to Dart mobile payment apps. A passenger can charge a card through M-Pesa, Tigo Pesa, Airtel Money and HaloPesa. The ticket vendor (MAXCOM) at the stations/terminals shall only be responsible to provide tickets for few numbers of guests with no Dartcards and for those who needs assistance.

It is investigated that during off peak hours the bus arrival time at stations/terminals is extended to 25 minutes due to few passengers instead of 15 minutes scheduled time. To eliminate long time stay at stations/terminals during off peak hours, DART should ensure that the 15minutes interval is properly monitored or exactly time schedule on off-peak hours should be displayed at stations/terminals so that to remove confusion and improve customer satisfaction.

Basing on the findings it is investigated that the current DBRT fair price of Tshs 650 should be reduced to 77% to cover for low and medium income passengers but also SUMATRA should come with categorized fair prices for DBRT based on the recommended passenger groups as elders/disabled, students/pupils and adults.

Furthermore, the research recommends that DART should provide education to the road users on rules and regulations governing DBRT operation. This will reduce number of jay-traffics and jay-drivers which will then reduce road traffic accidents along DBRT corridor. However the DART website, http://www.dart.go.tz should be improved to accommodate routes information, time schedules, rules and regulations, special events and system interruptions as they occur.

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Annexes

Figure A: Traffic congestion in Dar es salaam City before DBRT [8]

Figure B: Released congestion in Dar es salaam city after DBRT [45]