Assessment of the Contribution of the Bus Rapid Transit Systems to Climate Change Mitigation and Sustainable Development: The Case of Dar Rapid Transit Project in Dar es Salaam, Tanzania

Jones J. Helberth[1], Cuthbert Z. M. Kimambo[2]

Abstract

This paper assesses the contribution of Dar-BRT[3] System to climate change mitigation and sustainable development in the city of Dar es Salaam. As burning of fuel leads among the primary sources of greenhouse gases (GHGs), this paper explores and compares estimated amount of fuel burned among the three modes of transport in the city: personal vehicles, "Daladala" buses and Dar-BRT buses. Looking at each mode of transport, the paper finds that the Dar-BRT buses are using the least fuel and hence offer the greatest potential to mitigate climate change leading to promoting sustainable development. In addition, the Dar-BRT Project improves public transport services in the city by shortening transport time, reducing transport costs and making it more convenient mode of transport in urban. This is in line with the Sustainable Development Goals (SDGs), particularly goals number 8, 9, 11 and 13.

Introduction

As population and economy grow, people's needs in terms of goods and services also do increase. One of the significant social services of which the demand keeps on increasing in cities and towns is transportation. Although it has much negative social, economic and environmental impacts, urban transport is essential to the livability of the cities (Kin, Verlinde, Mommens & Macharis, 2017).Transportation in general has much environmental impacts associated with energy consumption and carbon emissions (Lade & Lawell, 2015).Various reports show that GHG emissions from the transport sector are increasing at a faster rate than any other energy using the sector (Attard, Budd & Hickman, 2016). In 2004, transportation sector was responsible for about 23% of world energy-related GHG emissions, of which about 75% came from road vehicles (Kahn *et al.*, 2007). Furthermore, the synthesis report of the Intergovernmental Panel on Climate Change (IPCC) argues that since the year 2000, emission of GHGs has been growing in all sectors excluding forestry, agriculture and other land use activities.

1 Assistant Lecturer, Institute of Development Studies, University of Dar es Salaam, Dar es Salaam, Tanzania. Email: helberth.jones@udsm.ac.tz/joneshelberth7@gmail.com Mobile: +255 757 452 268.
2 Professor, College of Engineering and Technology, University of Dar es Salaam, Dar es Salaam, Tanzania. Email: kimambo@udsm.ac.tz/cuthbertkimambo@yahoo.com Mobile: +255 754 281 680.
3 Dar es Salaam Bus Rapid Transit (Dar-BRT) involves two main partners, namely Dar Rapid Transit Agency (DART) and "Usafiri" (Swahili word for transport) Dar es Salaam - Rapid Transit (UDA-RT). DART is a government agency which is mainly responsible for hiring service providers, coordinating and supervising provision of transport services. UDA-RT is the service provider working under the DART Agency.

Since then, the transport sector has been releasing about 14% of all GHGs globally (IPCC, 2014).

GHG emissions from burning of fossil fuels are the primary drivers of global warming and climate change (Nocera, Tonin & Cavallaro, 2015). Kahn *et al*. (2007) and Stanley, Hensher and Loader (2011), argue that GHG emissions from the transport sector have a faster rate of increasing than any other sector that uses energy.

Making public transport more efficient, accessible, reliable and affordable will help to reduce GHG emission related to transport sector (Banister, 2000). According to Waterson *et al*. (2003), in order to cut CO_2 emission from road transport, a significant shift to public transport with 'zero carbon' is required rather than relying only on conventional buses and trains. One of the efficient public transport systems which have been identified to be suitable and affordable especially in developing nations is the Bus Rapid Transit (BRT) System (Shenghui *et al.*, 2010). In this regard, the paper assesses the contribution of the Dar Rapid Transit (DART) to climate change mitigation and sustainable development in Dar es Salaam, Tanzania.

Dar es Salaam City Transport, Tanzania

In 2003, the City of Dar es Salaam showed an interest to join the Sustainable Cities Initiative (SCI) that was aimed at building a more sustainable Dar es Salaam (URT, 2004). In fulfilling this, public transportation was one of the identified priority areas of development that has been a big challenge in Dar es Salaam city, especially during peak hours of morning and afternoon, when crowds of people are going to their working stations and back to their homes respectively. During these hours, in almost all busy roads of the city, traffic congestions and traffic jams prevail. This could be one of the significant limitations towards sustainable development as it adds economic costs to the people by wasting their time and slowing the delivery of goods and services. Likewise, traffic congestions multiply emission of GHGs into the atmosphere. According to Barth and Boriboonsomsin (2009), even in developed countries like the United States of America, surface transportation is a large source of GHGs emission contributing to the global climate change. In the industrialized countries, transport sector is the largest source of GHG emissions as compared to other sectors using fuel (Frondel, Schmidt & Vance, 2009).

The Dar es Salaam City Council had introduced an Integrated Transport Programme through the Bus Rapid Transit (BRT) system in order to improve public transit services in the city while preserving the environment (URT, 2004). This initiative is in line with the Tanzanian National Transport Policy of 2011 that emphasizes effectiveness, competition, efficiency, affordable services and environmental preservation (URT, 2011). Upon completion of the Project, the Dar-BRT will consist of six (6) corridors covering a total distance of 130.3 km, 18 terminals and 228 stations (DART, 2015). However, the interim service for Phase 1 corridor is already in operation since 10th May, 2016. As per DART (2015), mobilization for phase 2 and 3 development including system design is

ready. The whole project with six (6) corridors is expected to be ready by 2025 (DART, 2015).

The Dar-BRT Project is a sustainable transport intervention that addresses climate change phenomenon. This is in line with Asadabadi and Miller-Hooks (2017) who argued that climate change should be considered when introducing the future programs on the transport sector. Sustainable transport initiatives help to mitigate climate change in the transport sector (Schwanen, Banister & Anable, 2011).

This study has revealed that switching into Dar-BRT System helps to attain all the three dimensions of sustainable development, namely social, economic and environmental. *Fig. 1* below illustrates this very well.

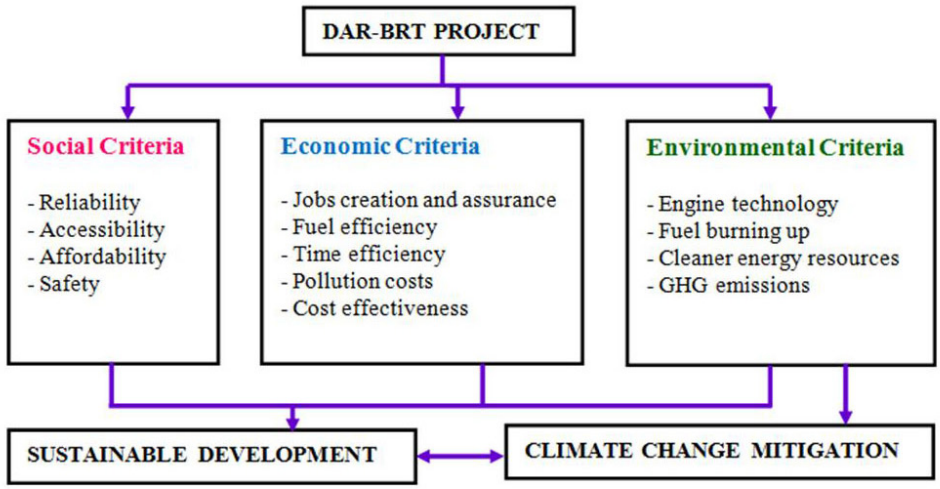

Fig.1: The Dar-BRT Project as a sustainable development intervention

Carrigan *et al.* (2013) point out that BRT systems reduce GHGs that contribute to global climate change as well as local air pollutants responsible to citywide air pollution and smog. Through the BRT system, reduction of GHG emissions can be achieved by replacing older technologies and smaller vehicles with newer cleaner high-capacity BRT buses as well as by reducing Vehicle-Kilometers Travelled (VKT) (Carrigan *et al.*, 2013).Experience from the Guangzhou-BRT system shows the BRT system contributes significantly to local and national sustainable development goals (CCAP, n.d.).

The Brundtland Commission (WCED, 1987) argues from a sustainable development point of view, environment and development are inseparable. Therefore, any project or development that is environmentally sensitive, such as the Dar-BRT Project, is considered to be sustainable as it addresses also both environmental and social concerns. According to Carrigan *et al.* (2013), investments like freeways, flyovers and more sustainable mass transit like the BRT are very significant areas in achieving sustainable development, that is to

say, development with the least side effects on the society and environment.

Methodology

Description of the Study Area

The study case was the city of Dar es Salaam, the only region in Tanzania implementing the BRT system. *Fig. 2* below is the map representing the specific study area within Dar es Salaam that is the Phase 1 of Dar-BRT.

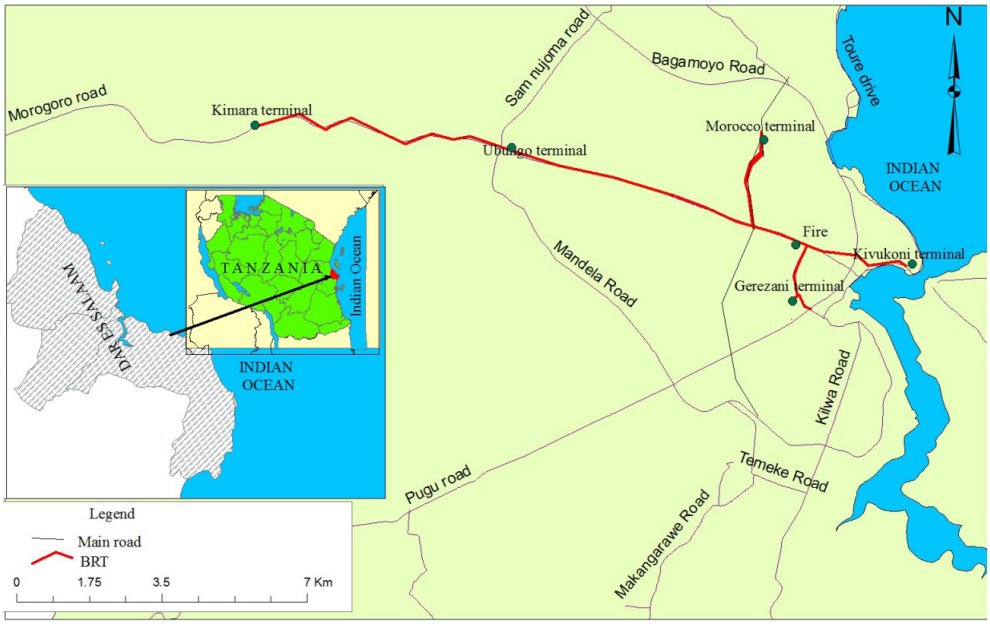

Fig. 2: The study area of Dar-BRT Phase 1 Corridor

The sampling frame involved streets where Phase 1 of Dar-BRT Project has already started its operation. Among others, those streets include Mbezi, Kimara, Ubungo, Manzese, Magomeni, Morocco, Kariakoo, City Centre and Kivukoni. *Fig. 2* illustrates the Dar-BRT Phase 1 corridor very well with its five terminals.

Sample Size and Data Analysis

A manageable representative sample size of about 100 respondents was used in this study, specifically for administering a questionnaire. Reference was made to Ary *et al.* (2006) who argue that the representativeness of the sample is more important than the size of the sample. In addition, the study involved some key informants whose number varied according to their accessibility.

Public Transport Type in Dar es Salaam

According to the data given by the SUMATRA officials at Ilala Coast Zone

Office on 6th February 2017, the 140 Dar-BRT Higher Capacity Buses (HCBs) have managed to replace at least 261 out of 570. This is equivalent to at least 46% of all "Daladala" buses that used to provide transport service alongside the Morogoro Road corridor. Fig. 3 illustrates the number of "Daladala" buses before and after the start of Dar-BRT services passing through the Morogoro Road corridor as of 6th February 2017.

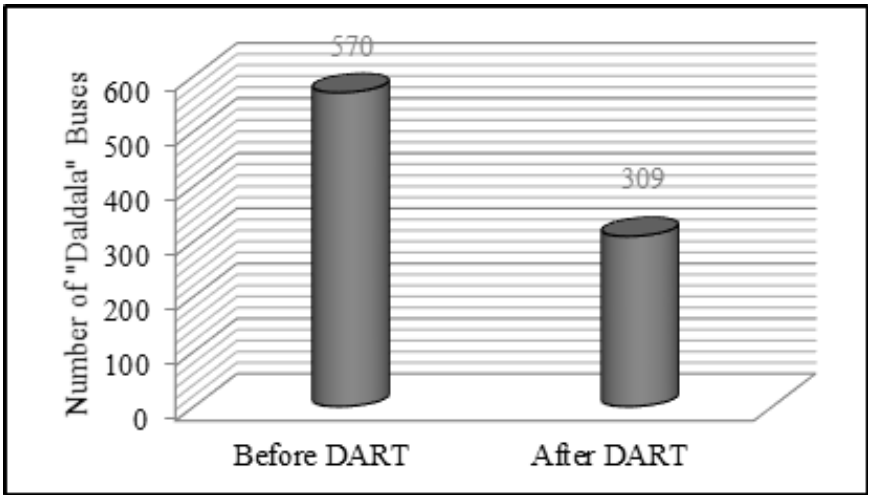

Fig. 3: Number of "Daladala" buses alongside the Morogoro Road corridor

Majority of all respondents indicated that Dar-BRT has contributed to promote the use of Non-Motorized Transport (NMT) means such as walking and bicycling due to the presence of supporting infrastructures beside the roads as observed by this study. The following plates tell more on this.

Plate 1: Walking alongside the Dar-BRT lanes

Plate 2: Movements alongside the Dar-BRT Phase 1 corridor

Results

The reaserch results show the coming of 140 HCB[1]s (the UDA-RT trunks and feeder buses) has reduced the number of "Daladala" buses and personal vehicles from entering the city centre and hence reducing burning of fossil fuels, both petrol and diesel by at least 46% for "Daladala" and 5% for "personal vehicles". This has also resulted into reduction of traffic congestion in the city. Using a Euro 3 Engine Technology[2], the Dar BRT buses have been certified to be environmentally friendly by meeting both national and international emission standards according to NIT[3] and TBS[4] officials.

Status of Respondent Related to Transport Means

This study has discovered out of the 91% of all respondents who were using public transport before the coming of DART, a majority of them (about 87%) were using "Daladala" and the remaining (about 4%) were using other types of transport such as "Bodaboda", trains and ferries. After the start of DART, the study reveals out of the 96% of all respondents who are using public transport around the Morogoro Road corridor, 66% commute with the Dar-BRT. The percentage of "Daladala" commuters alongside this corridor has dropped from 87% (before DART) to 29%. This means more respondents alongside this corridor are now commuting by the Dar-BRT instead of the "Daladala. *Fig. 4* represents this information well.

1 Higher Capacity Buses
2 Engine that meets European Emission Standards and thus have fewer impacts to the environment
3 National Institute of Transport in Tanzania
4 Tanzania Bureau of Standards

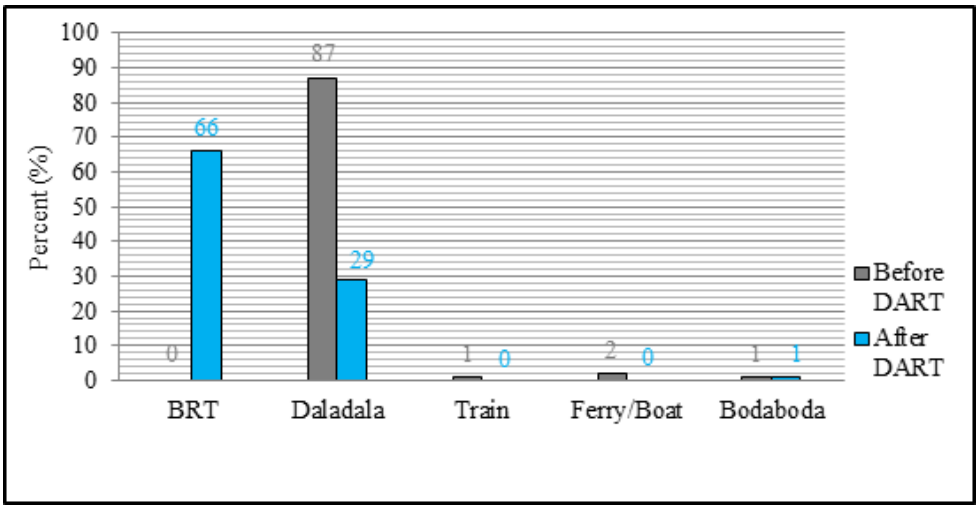

Fig. 4: Types of public transport before and after DART

Estimated Fuel Use of Vehicles alongside the Dar-BRT Phase 1 Corridor

As observed by the study, the average carrying capacity of each private vehicle, "Daladala" bus and Dar-BRT bus is 5, 35 and 170 passengers respectively. Table 1 below shows fuel consumption of vehicles assuming a single mode of transport is left to operate itself in the Dar-BRT Phase 1 corridor, a 21km long, from Kimara to Kivukoni.

Table 1: Fuel needed to transport 170 passengers

Modes of Transport	Average No. of Vehicles to Carry 170 Passengers	Average Amount of Fuel Consumed per One Vehicle **Litres**	Total Amount of Fuel Burned to Carry 170 Passengers **Litres**
Private Vehicles	34	2.1	71.4
"Daladala" Bus	5	3.0	15.0
Dar-BRT Bus	1	6.0	6.0

Data provided by the Dar-BRT through their Magazine, the number of passengers using Dar-BRT buses has now reached 260,000 from 38,000 passengers per day during the start of the project, May 2017 (UDA, 2017). Table 2 below shows the estimated amount of fuel needed to transport those 260,000 passengers per day using the three modes being compared.

Table 2: Fuel needed to transport 260,000 passengers

Modes of Transport	No. of Vehicles/ Trips per Day	Type of Fuel Used	Total Amount of Fuel Used per Day **Litres**
Private Vehicles	52,000	Petrol	104,000
"Daladala" Bus	7,428	Diesel	22,284
Dar-BRT Bus	1,529	Diesel	9,174

3.3 Estimated Costs on Fuel Per Day

If a single mode of transport, among the three modes being compared is left to transport 260,000 passengers per day, total average costs on fuel (as per January - July 2017 prices in Dar es Salaam) will be as shown in Table 3 below.

Table 3: Average costs on fuel per day to transport 260,000 passengers

Modes of Transport	No. of Vehicles/ Trips per Day	Amount of Fuel Required per Day **Litres**	Type of Fuel Used	Average Price of Fuel per Litre **TZS**	Total Costs on Fuel per Day **TZS**
Private Vehicles	52,000	104,000	Petrol	2,060	214,240,000
"Daladala" Bus	7,428	22,284	Diesel	1,900	42,339,600
Dar-BRT Bus	1,529	9,174	Diesel	1,900	17,430,600

Discussion

Literature reviews and findings from this study indicate there is a strong relationship between the BRT systems and fuel use, a primary driver of GHGs causing climate change. It suffices to say Dar-BRT Phase 1 Project has contributed to reducing emission of GHGs and hence mitigating climate change. Moreover, the Dar-BRT Phase 1 Project, as a sustainable development project, has contributed to protecting the environment and at the same time fulfilling the social and economic demands. Environmentally, the Dar-BRT system emits less volume of GHGs as compared to the "Daladala" buses which were dominant before the start of DART services in Dar es Salaam. With Dar-BRT, the rate of emission in a given place has been reduced a lot by the reduced travelling time and congestions. Socially, the study finds that although there are a lot of complaints against the Dar-BRT system on the social wellbeing of its passengers,

still majority of respondents show positivity with the system because most of the significant aspects of social wellbeing have been addressed.

Economically, the Dar-BRT seems to promote economic development in three areas as described here under:

(a) Increase in the working hours and thus stimulating increased production as passengers are now able to schedule when and where to be at a given time.

(b) Reduction in fuel consumption per day by at least 51% helping the nation to save a big amount of money from fuel buying that would be put into other investments.

(c) Reduction in social costs as a result of environmental protection, which in turn has managed to reduce emission of smokes and noise which is likely to be very much dangerous to people's health. Likewise, reduction in accidents saves the government and people's incomes on curing casualties. It also ensures healthy and reliable labor force in the country.

Conclusions

The transport sector is one of the major sectors to be put into consideration when addressing climate change because of its fast growth rate and the corresponding impacts it has on the environment.

If we really need to mitigate climate change then we are required to implement our projects in the light of sustainable development. The Dar-BRT System, as one of the sustainable development projects, stands out as a catalyst in achieving four (4) SDGs, namely Goal 8 of Decent Work and Economic Growth, Goal 9 of Industry, Innovation and Infrastructure, Goal 11 of Sustainable Cities and Communities as well as Goal 13 of Climate Action.

The city of Dar es Salaam can achieve SDG 8 of Decent Work and Economic Growth through the Dar-BRT System as its people get to their workplaces in time. This has resulted into increased working hours as well as ensuring people's job security. The Dar-BRT system – a quality, reliable, sustainable and resilient system for mass transport - is a crucial driver for economic growth and the social wellbeing. This is in line with SDG 9 of Industry, Innovation and Infrastructure. In order to achieve SDG 11 of Sustainable Cities and Communities, the concern of urban planning, particularly investing in sustainable public transport like the Dar-BRT Project especially in developing countries is very crucial. The study results show the Dar-BRT Project is environmentally friendly and cost effective by consuming less fuel.

The results of this study have confirmed that the Dar-BRT Phase 1 Project has contributed to reducing fuel burning and hence emission of GHGs not only in Dar es Salaam but also all over the world, simply because any mitigation action against climate change affects the whole world. This is in line with SDG 13, Climate Action. Thus, the BRT systems are one of suitable measures to be taken against climate change phenomenon through transportation sector.

Recommendations

Phase 1 of the Dar-BRT, one out of the 6 phases, signifies the coming of a new clean Dar es Salaam. However, these initiatives should not end up in Dar es Salaam only. The concept should be introduced in the other fast growing cities like Mwanza, Mbeya, Arusha and Dodoma.

Furthermore, it is recommended that the Dar-BRT should switch to CNG[1] fuel instead of diesel in order to make it more meaningful. This would further increase the GHGs that are cut-off. Likewise, further efforts should be made on innovation of other means of cleaner transport, such as the introduction of hybrid vehicles and electric trains in the large cities and towns of Tanzania.

Integrating climate change and sustainability dimensions on our projects require political will. Unless the political leaders become active and responsible to take actions now, they will be responsible for destroying this planet later on. A policy that prohibits the use of "daladalas" and personal cars in busy cities and towns should be introduced in the long run.

Last but not least, this study has only revealed that Dar-BRT has reduced fuel consumption, which in turn leads to reducing emission of GHGs, but it has not quantified the amounts of GHGs reduced. It is, therefore recommended further studies be undertaken in this area. Such studies should quantify the amounts of GHGs which have been avoided following implementation of the Dar-BRT Project.

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