TRAFFIC CONGESTION IN TANZANIAN MAJOR CITIES: CAUSES, IMPACTS AND SUGGESTED MITIGATIONS TO THE PROBLEM

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ABSTRACT

Traffic congestion is considered to be state or condition on any transport network resulting from its increased use and is characterised by increased traffic queuing and a near traffic stand-still. There are various causes, impacts and approaches to alleviate traffic congestion problems. One of the several negative impacts of traffic congestion is the increased air pollution emissions.

The paper strives to associate the increased air pollution emissions in Tanzania major cities' roads to the increasing traffic congestion and seeks to understand the main reasons for the bottlenecks hindering implementation of the previous mitigation measures out of which recommendations to alleviate the problems are suggested.

Although major air emissions in large cities are concerned with particulates and photo-chemical smog, the discussion herein focuses and limits itself the problem of carbon oxides (CO_X) gases in the Dar es Salaam city caused and exacerbated by traffic congestion problem. Pollution aspects of CO_x in our national roadways are very often marginalised if not forgotten completely in most discussions on road traffic congestion problems.

The paper therefore presents and discusses results from a study conducted on the Tanzania transport sector covering a period of twenty (10) years and attempts to build arguments showing how and why vehicular traffic congestion can be blamed as one of the main culprits for the alluded environmental and related problems.

Although the main pollutants studied were CO_2, CH_4, N_2O, CO, NO_X, NH_3, non methane volatile organic compounds, SO_2 and particulate matter, which normally give rise to a chain of reactions (photochemical reactions) and photochemical smog, pollutants of main interest were CO_2 and CO. It was found that CO_2 and CO emissions have been increasing annually, which suggests a need for effective intervention measures to stop and, or reverse the trend.

Some of the identified causes for traffic congestion, long queues and therefore high pollution emission levels in Dar es Salaam and in other city roads include but are not limited to fast increasing human population, the number and usage of vehicles, inadequate and, or poorly maintained roads and storm-water systems as well as poor traffic attitudes and lack of traffic rules enforcement.

Recommendations have been put forth to decongest traffic and reduce air pollution emissions including redesigning of parts of the cities and city roads, strengthening and

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enforcing existing legislations and policies, switching to hybrid road/rail/water transport, encouraging positive attitudinal and behavioural changes, providing reliable, efficient and convenient alternative modes of transport and simple but basic amenities including walkways and safe bikeways as well as reviving the previous common transport (transport sharing) and, or car pooling practice by companies/government and other agencies.

***Keyword:** Vehicle traffic congestion, Air pollution emissions, Traffic jam.*

1.0 INTRODUCTION

Road transport is an inescapable requirement to the human civilization where it provides considerable economic and social benefits to the society. For example road transport allows pursuance of specialization in production opening opportunities for industry to exploit economies of scale, density and scope. At individual level, it provides general mobility where it affords access to diverse employment opportunities enabling a wide range of recreational and social activities to be reached and enjoyed. The problem arises when, due to institutional and technical factors road transport tends to be less than fully efficient and excessively intrusive on the environment.

Traffic congestion (road transport congestion) is considered to be a state or condition on any transport network which results from its increased use. Congestion is most common for physical use of roads by vehicles and is manifested when traffic demand is great enough such that the interaction between vehicles slows the speed of the traffic stream. *Extreme congestion* usually happens as the demand approaches the capacity of a road (or the intersection along the road) while a condition described as *traffic jam* (*or traffic snarl-up*) occurs when vehicles are fully stopped for periods of time. Congestion in Dar es Salaam is characterised by slower speeds, longer trip times, increased pollution, queuing, more frequent accidents and, or attacks which may result to injuries, loss of life, economy or both.

The fast expanding population, high number and usage of vehicles, rapid urbanization, inadequate, narrow and/or poorly maintained roads and storm-water systems as well as some old road-unworthy vehicles, inadequate town, land-use, and traffic plans and implementation, negative traffic attitudes as well as lack of enforcement of traffic rules have been identified to be some of the causes that contribute to traffic congestion and high pollution levels.

Increased air pollution emissions can be argued from the fact that since traffic congestion involves more vehicles, longer queues and trip times, it is more likely and logical that the vehicles will emit more pollutants than if there were less traffic, shorter queues and trip times.

Health, productivity, economic and social effects of air pollution emissions as a result of increased use of automobiles and traffic congestion are well known. Transportation affects *public health* in several ways, including traffic risks, pollution exposure, physical activity, affordability and physical access to medical services (http://www.vtpi.org/tca/tca0503.pdf). The Table 1a below summarises some of the transportation health impacts.

Table 1a: Transportation Public Health impacts

Health Enabling	Health Damaging
▪ Affordable access to health promoting services and activities (medical care, health, food, recreation, school, employment etc) ▪ Exercise, use of active transport modes such as walking, cycling etc	▪ Traffic accidents ▪ Air pollution emission exposure ▪ Noise pollution exposure ▪ Stress and anxiety ▪ Constraint on active transport (walking and cycling) due to traffic ▪ Financial cost burdens due to high transport costs

Apart from their health effects, automobile emissions negatively affect the environment, the climate and structures and may reduce productivity directly or indirectly. In many cases fuel is used in excess during traffic congestion. Also delays as a result of traffic congestion may lead to far reaching economic and social consequences.

Due to these facts, the design of cities for sustainable transport system should aim to provide efficient, *effective, adequate* and *convenient* mobility and *accessibility* to all road users, in a *safe* and environmentally acceptable condition. These challenges are at times conflicting which makes the traffic congestion problem complex and difficult to solve. For example, while segregation of road space for bicyclists and pedestrians from motorised traffic as well as speed reduction may be necessary to reduce problems, it could restrict *mobility* of cars and add to the pollution problem. Also while an increase in the average vehicle speed may reduce emissions, it can on the other hand result in an increase in accidents rates.

This suggests that traffic congestion should not always be considered a result of failure to be blamed on the inefficiency and ineffectiveness of planners and managers. It can also be an inevitable by-product of vibrant and successful economies and cities. In the same vein, traffic congestion and enhanced emissions in large cities could also be considered to be an unfortunate consequence of prosperity and a drag of an otherwise high level of accessibility, and not a cause for economic decline and urban decay.

1.1 The Dar es Salaam City - Size

The total kilometre road network available in Dar es Salaam is not sufficient for the number of vehicles and road users' requirements.

The total surface area of Dar es Salaam City is 1,800 square kilometres, comprising of 1,393 square kilometres of land mass. The city occupies about 0.19% of the total Tanzania landmass area but accommodates more that 45% of all registered vehicles in the country (Table 2). The three Dar es Salaam districts namely Kinondoni, Ilala and Temeke make up the city with Temeke Municipality occupying the largest land surface area followed by Kinondoni and Ilala which is the smallest of the three.

1.2 Population and Roads Network and Pattern in Dar es Salaam

Dar es Salaam is Tanzania's main commercial and business centre with current population of over 3 million people and population growth rate of about 2% (Table 2) due to among others high migration from the rural to the city. Consequently it has always been difficult to provide social services that fully meet public requirements. One area that has always not been fully met is the provision of adequate transport system to decongest transport congestion in the city. Despite efforts by the city leadership and the Government to expand and improve the city roads network it has remained largely underdeveloped compared to its expected needs. Most roads are still narrow with poor surface conditions (Table 1b), inadequate drainage and in some cases without drainage. The Dar es Salaam road network covers a total of about 2,094.4 km of which only 525.1 km are paved (Figure). The unpaved roads (1,569.3km) are generally poorly maintained, lack proper maintenance and are misused in some cases. Also due to poor planning and other factors, the quality of some of the roads (including some of the newly built roads) has remained poor. Some of the roads do not have walkways or bicycle-ways, leading to non-segregation of traffic. Besides, some of the city dwellers have constructed structures on reserved areas, hindering smooth traffic flow and increasing congestion and air emissions.

The city has over 1,100 kilometers of open lined ditches and 600 kilometers of piped storm water drainage which are not enough for the city requirements and require expansion and improvement. Lack of regular maintenance and the habit of dumping refuse into the drains has impaired the proper functioning of the ditches and drains and exposes the city to frequent flooding due to inadequate drainage and blockage of the ones existing. This situation slows down traffic movement and increases the traffic queues as well as the missions, especially when considering the fact that some of the vehicles in the city roads are old and in some cases unmaintained. Undeniably the city road network adds to the already pathetic congestion and vehicular emission problems in the city.

Figure 1: The Administrative Districts (Municipalities) of Dar es Salaam
Source: City Director, 2004

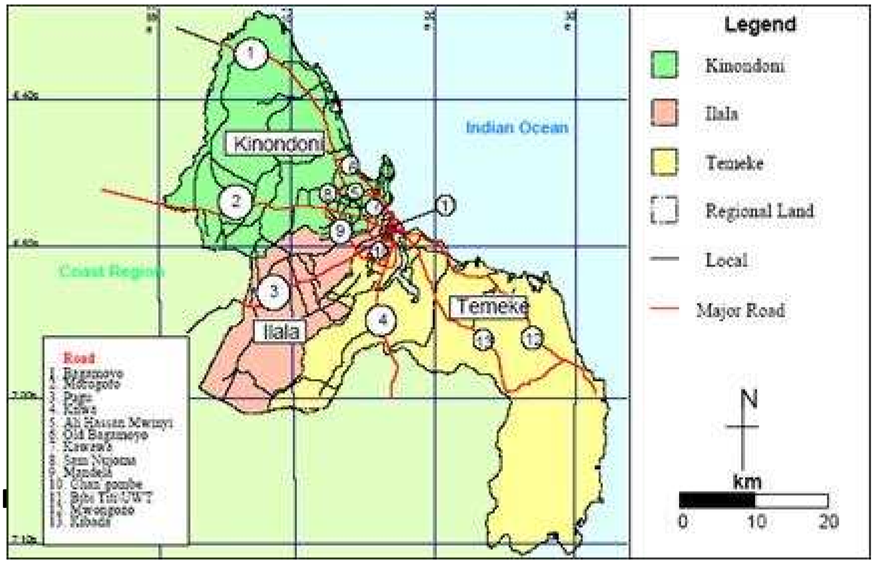

Table 1b: Type and length of Road Network in Dar es Salaam

(http://dsm.go.tz/kurasa/narabara_majengo/barabara/index.php (9.10.2011)

Responsible	**Length (km)**	**Type of Network Road (km)**		
		Tarmac	Gravel	Earth
Tanroads	494.3	211.4	282.9	
Ilala Municipality	429	132	80	217
Kinondoni Municipality	692.7	114.7	315.25	262.752
Temeke Municipality	478.4	67	411.11	
Total	**2,094.4**	**525.1**	1,569.3	

Undisputedly network road type, quality and length contribute to the traffic congestion in cities.

In an attempt to understand relations governing usage of motorised transport and how it is related to the land-use, Meyer and Miller (2001) considered features and patterns of urban mobility to consist of work trips, shopping trips, social or recreation trips, business trips and school trips. Depending on how the city has been designed, its population, the available infrastructure, and number of cars on the roads, the situation may or may not lead to traffic serious congestion and air pollution emissions. Figs. 3 to 6 are used to clarify the discussion.

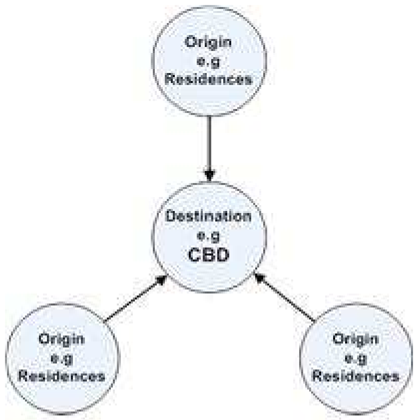

Fig. 3: Polycentric star-type pattern

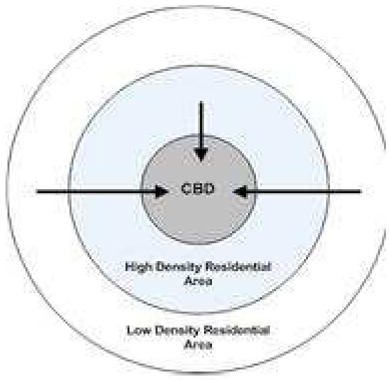

Fig. 4: Concentric type pattern

Permana (2005) suggested that the way a city has been designed ultimately determines the origin of travel, destinations and distances travelled – thus traffic congestion and levels of air pollution emissions. City design thus affects transportation mode choices as well as individual travel patterns. The movements of urban citizens can be considered to exist in four different general types (Fig. 3-6) with respect to the *origin-destination* (O-D). The movements affect the physical mobility of citizens, and may require motorized transport demand, leading to congestion, transport energy wastefulness and air pollution in some cases. The 4 patterns are:

- *Polycentric, star-type* plan (Fig 3) considers central business destination (CBD) and all/ most residential (origin) destinations outside the town – i.e. origin-destination (O-D) separation;
- <u>Concentric type</u> (Fig. 4) considers the city to be concentric type with high density areas close to the centre and low density areas in the city peripheries. Like in Fig 3, the commercial business area is at the centre with large origin-destination separations requiring motorised transport. Fig. 3-4 partly describe the city of Dar es Salaam;
- *Polycentric multi-linkage* type (Fig 5) is characterised by *partial origin-destination* separation; and
- *Full origin-destination separation* (Fig. 6) which has several origins and destinations with linkages of every origin to the available destinations.

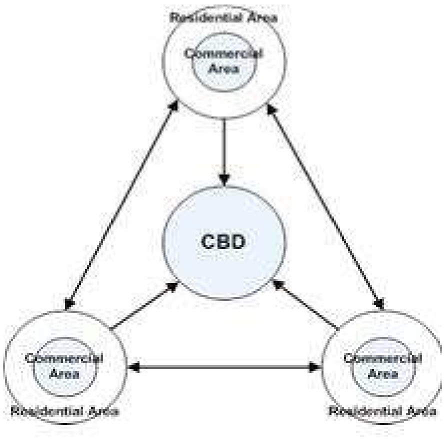

Fig. 5: Polycentric multi-linkage pattern

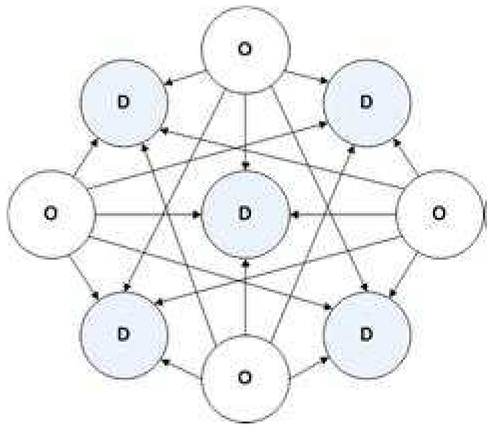

Fig. 6: Full origin-destination type pattern

The patterns suggest that all conditions being equal and assuming equal total number of vehicles in the city, the more the number of connecting arrows, the less the vehicle density and congestion and the less is the air pollution emissions and vice versa. The assumption suggests that the last two patterns will lead to least congestion and least air emissions. Unfortunately the pattern of the Dar es Salaam city with its three districts is as Fig 3 and 4, (suggesting heaviest congestion and pollution is expected).

Irrespective of the nature of any particular trip, where moderate to long travel distances must be covered, motorized transport is generally preferred and required. It is therefore evident that the choice of whether to use motorized or non-motorized transport mode is affected by land use – city design and O-D distances. If there is "no O-D separation" or if a trip is "within walking distance separation", motorized transport may not be necessary unless there are other overriding reasons such as weather condition, time constraints - the need to arrive at the destination in good time and, or other safety and economic reasons. Consequently, "no energy" (non-human) mode would be preferred for transportation purposes and there will likely very little, if any, traffic congestion or *emissions* released.

Hanson (1995) argued that although the nature of these trips may vary from one city to the other, the classifications of urban mobility will still consists of the following general features:

- Work trips made to a person's place of employment, e.g., public or private institutions, manufacturing plants, retail stores or shopping malls;
- Shopping trips to any retail outlet, regardless of the size of the store and whether or not a purchase was actually made;
- Social trips made for social activities, e.g., to go to parties or visit friends, sports;
- Recreation trips made to go to entertainment, cultural or other recreational facilities;
- School trips made by students at any level to a learning institution;
- Business trips usually defined to include trips made from a place of employment to another destination in the city; and
- Home trips including any trip ending at home.

The suggestion by Hanson (1995) fits well with the realities in Dar es Salaam where road transport has been, and is still a major means of moving people, goods and services to and from different kinds of business activities destinations. Five main trunk roads (Morogoro, Bagamoyo, Nyerere/Pugu, Kilwa and Mandela/Sam Nujoma roard) connect the city's suburbs to the city centre - Commercial Business District (CBD) where most offices and business destinations are located and have a total length of 126.2 km. The pattern looks like and is close to a *star pattern* (Fig. 3) and can be considered to be an ineffective town (land use) plan. The pattern leads to traffic congestion and *air emission* problems particularly during peak and rush morning and evening hours. The long traffic queues are also experienced during heavy rains and bad/adverse weather conditions.

The traffic congestion and its consequential *air pollution emissions* can therefore be attributed to the increased number and use of cars in the limited and insufficient road networks. The increasing number and use of cars can be attributed to various reasons including:

(i) An expanding population that is not supplied with equally sufficient infrastructure;
(ii) Non-use or inadequate use of urban planning paradigms to check such problems as urban sprawls, known to increase dependence on cars especially where convenient and efficient public and, or mass transport is lacking;
(iii) Lack of understanding and, or implementation of relevant policy tools that can be used to influence attitudinal and behavioural changes of road users and the general public;
(iv) Lack of appreciation of the role and need for investment in sustainable infrastructure, e.g. walkways and bikeways, good public transport, including light rails, waterways, and other forms of mass transit;
(v) Insufficient understanding of circumstances and motivations that lead to increase in car ownership;

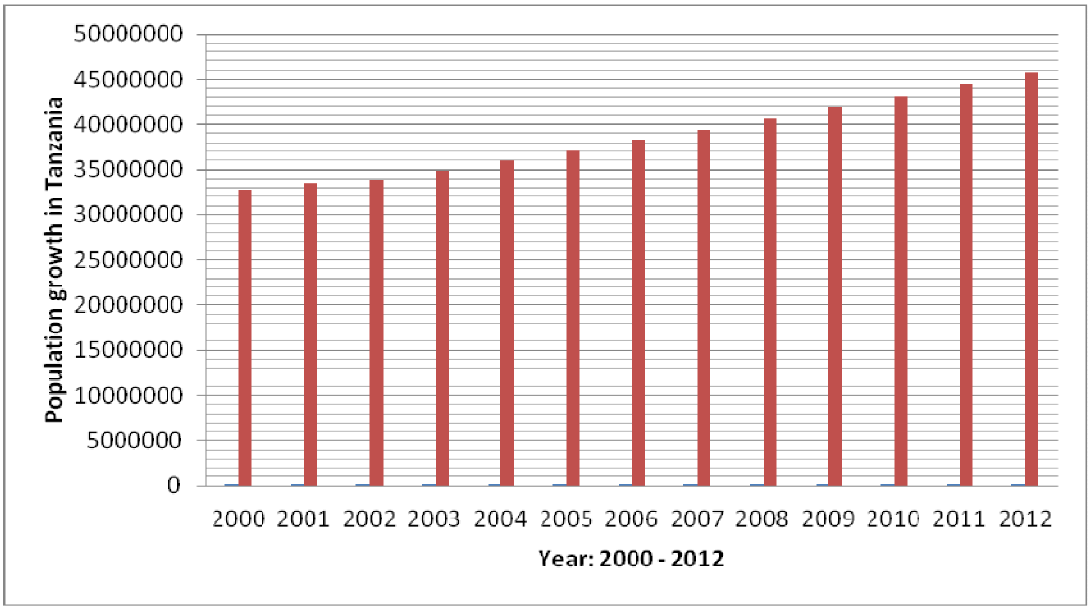

Fig. 7: Annual population growth in Tanzania: 2000 - 2012

Source:
http://www.wikipedia.org/wiki/Demographics of Tanzania with 2 % growth rate
http://www.worldbank.org/transportresults (9.7.2011) - with 10% projected growth rate
http://www.tanzania.go.tz/population.html (16.8.2011)

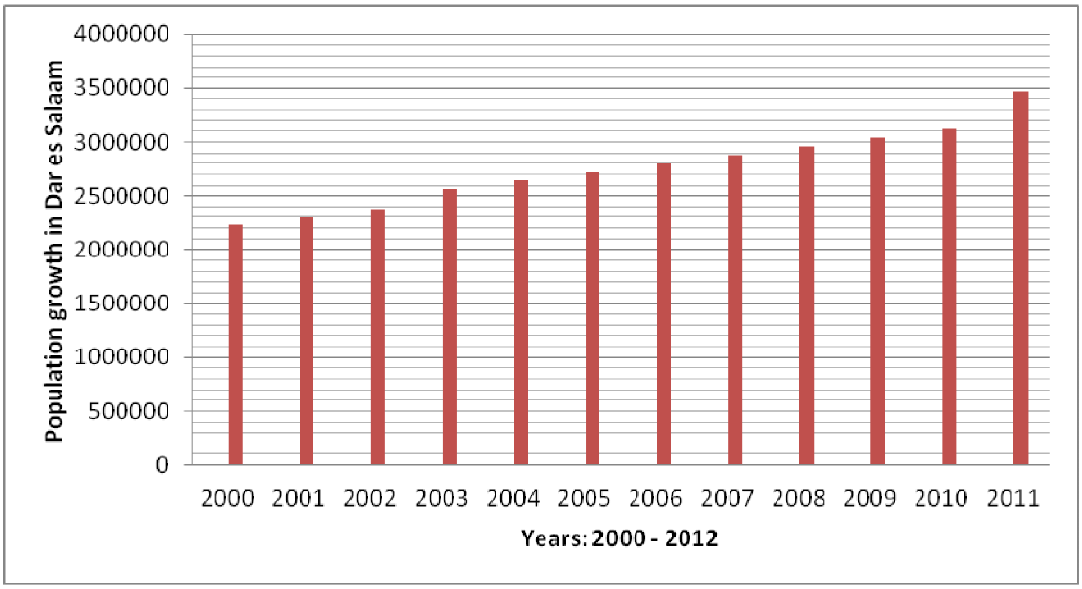

Fig. 8: Annual population growth in Dar es Salaam: 2000 - 2012

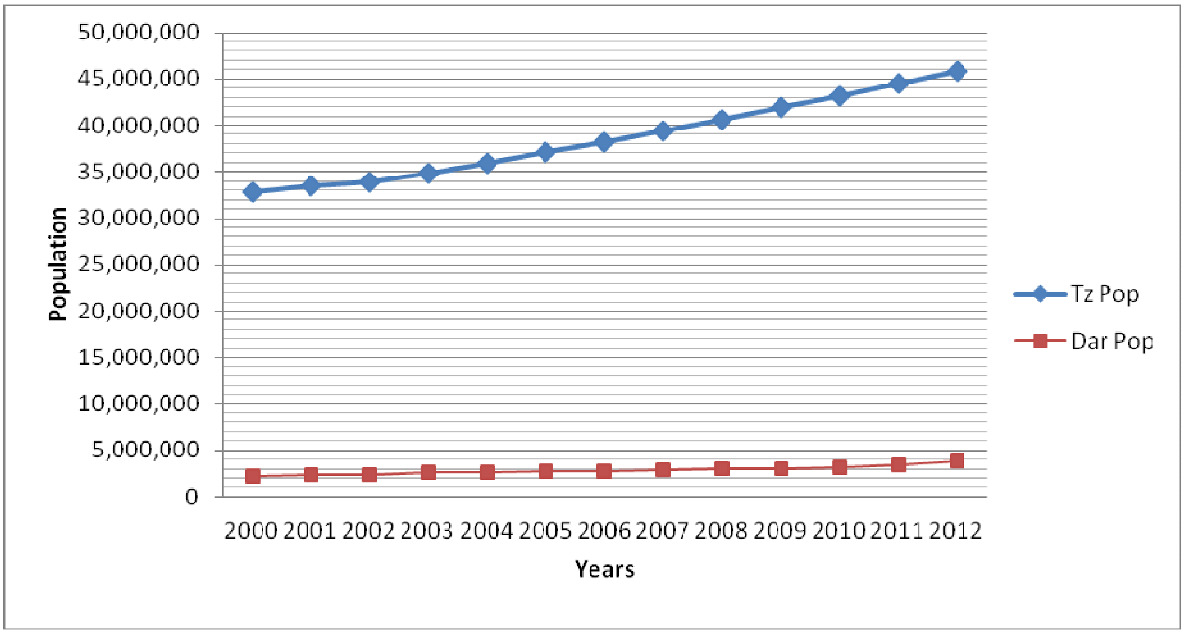

Fig. 9: Comparison of population growth in Tanzania and Dar es Salaam: 2000 - 2012

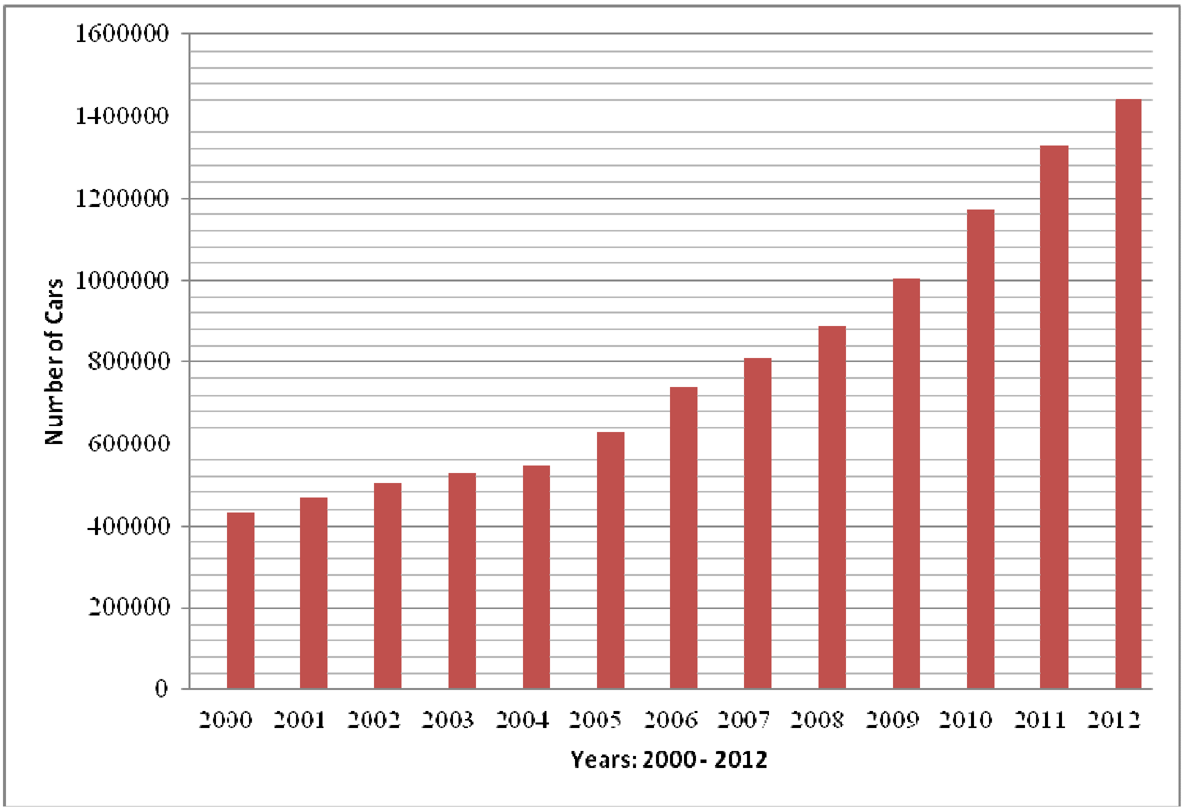

Fig. 10: Annual vehicles increase in Tanzania: 2000 - 2012

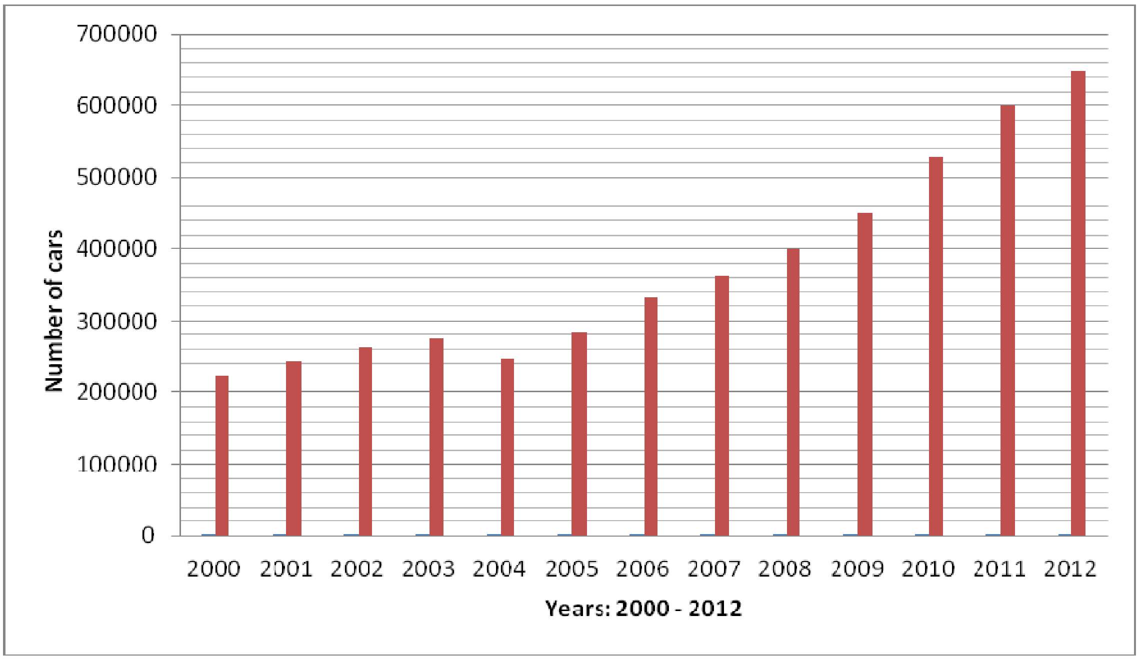

Fig. 11: Annual vehicles increase in Dar es Salaam: 2000 - 2012

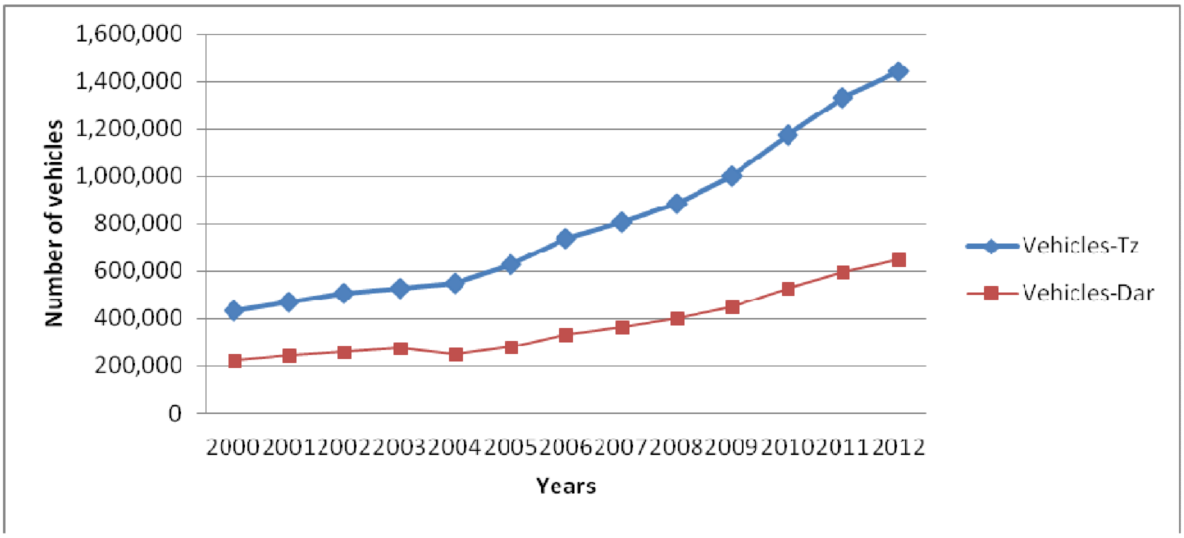

Fig. 12: Comparison of vehicles increase in Tanzania and Dar es Salaam: 2000 - 2012

Figs. 7 - 12 show how the population and number of private cars (excluding government, government institution military vehicles) have been increasing in Tanzania and Dar es Salaam from year 2000 through 2012 (TRA, 2011). The information is based on the assumption that as of 2004, **45**% of all registered cars in the country remain in Dar es Salaam. The percentage was estimated at 52% until 2003 (APINA, 2003) and close to 70% by some TRA officials. It is also based on the assumption that that about 15% of all registered private cars are government owned. It is striking to note that while about more that half of all vehicles are to be found in Dar es Salaam, they are owned by less than 10% of the country population and in less that 0.5% of the total area of the country. This information can already give a hint on the extent of road traffic pollution to be expected in Dar es Salaam if it were compared on a 1-to 1- basis with the corresponding national data.

Table 2 Number of busses in towns and regions http://www.mof.go.tz/mofdocs/Micro/eco_report/

Region	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Dodoma	150	170	220	154	167	136	142	405	n.a
Arusha	1,118	1,045	837	892	1,367	1,255	1,607	1,620	n.a
Mbeya	355	475	544	375	1,180	1,115	1,433	1470	n.a
Tanga	120	169	136	105	162	93	184	313	n.a
Mwanza	660	776	886	892	1,190	1,290	1,370	1,152	n.a
Dar'Salaam	5,801	6,600	7,000	8,972	6,144	5,716	6,043	7,573	n.a
Others	881	2,044	1578	1530	853	1411	1755	2181	n.a
Total	**9,085**	**11,279**	**11,201**	**12,817**	**11,063**	**11,016**	**12,534**	**14,714**	n.a

n.a = Figures were not available

Table 2 indicates that annual population growth rate for the city of Dar es Salaam is about 6-8% over the period of 12 years (200-2012). Over the same period, the fleet of cars increased at a rate of 19% annually! Table 2 indicates that the number of busses in Dar es Salaam over the last ten years have proliferated and are contributing greatly to the problems of traffic congestion and air pollution emissions in the city.

1.3 Persisting Traffic Congestion and Emissions Problem

From the viewpoint that economic growth is a means to achieve development goals, the transport sector has and will continue to be a driving force for growth. Unfortunately in the absence of proper guiding policies and strategies, the sector has contributed significantly to the problems of congestion and emissions which adversely affect local and regional environment, life of organisms as well as climate change. The concern about the growing number and use of vehicles has therefore been related to traffic congestion and emissions that that are deleterious to the life of the organisms and the environment. Inspite the previous there has not been much improvement. Some of the reasons why traffic congestion and emissions problems have become persistent in Dar es Salaam and Tanzania include the following:

(i) Ever expanding human population in the cities as well as the corresponding increase in the number and use of vehicles. The traffic congestion and related air emission problem in Dar es Salaam is also compounded by a high number of some slow moving large and heavy trucks into the city as well as an increasing number of old and unmaintained vehicles in the city roads;

(ii) Lack of adequate long-term physical plans (aiming beyond 50 years ahead) as well as ineffective management, implementation and enforcement of the city master-plans, policies, strategies and by-laws;

(iii) Lack of effective, reliable, and convenient alternative mode of transport. Public transport in Dar es Salaam city is generally unprofessional, poor, unsafe inefficient and lacks customer-care, quality and safety angles desired by users. The drivers and bus conductors are untrained, lack adherence to driving rules and regulations, disorganised and motivated by their pursuits to meet daily collection targets for the owners rather than offer state-of-the-art services. Consequently one very often sees reckless driving and parking, overloading, overcrowding, shortening of routes and similar especially during peak hours which compound instead of reducing traffic congestion and emission problems in the city. The city's BRT[2] project for alternative public transport aims to reduce CO_2 by 430,000 tons annually until 2025 and by 1.0 million tons annually beyond year 2025. Implementation speed for the project is unfortunately rather slow.

(iv) Inadequate and poorly maintained road infrastructure which lacks basic and simple amenities e.g. safe walkways, bicycle ways convenient and accessible to public and, or mass transport. Some of the access and network roads are too narrow, not

[2] BRT = Bus Rapid Transport, a fast moving busses project to reduce congestion and pollution in the city of Dar es Salaam

paved, lack side drainages/ditches and very often are characterised by potholes making them unsafe and leading to congestion. Observation indicates serious problems – (bottle-neck) to traffic flow at cross-roads requiring either expansions and, or redesign for over-pass and, or overpass and other possible fast outlets from the road-crosses. The situation is worse when it is rainy and, or where large and old and un-maintained vehicles are involved The main reason being that most of the roads in use in the city were built during the first phase of the Government (1961-1980) when the average population of Dar es Salaam was about 500,000 people only. When the main arteries roads are congested one very often finds '*spill-over effects*' (rat running) to the secondary and feeder roads as an alternative route. Unfortunately the chosen alternative route affects neighbourhood amenity, pollutes the environment and may create other more serious negative problems. While the population is now about 4 million, the infrastructure has remained generally the same. The congestion in the city signals two possible causes:

- Improved economic ability of the people;
- Inability of the Government to improve the existing infrastructure; or
- Both the above,

(v) Inadequate and, or ineffective legislation and policies that have failed to consider city/national political economy or stage of development at the start of project, match it with the reality and extrapolate it to the next 50 years or so ahead before a project is launched;

(vi) Ineffective or weak legislation, public policies, planning and management tools to address traffic congestion and emissions. This has in some cases resulted to increased tear and wear levels due to idling in traffic, acceleration, deceleration and braking as well as wasted fuel leading to higher emission levels;

(vii) Lack of critical mass of institutionalised decision making persons and organs;

(viii) Lack of recognition and implementation of positive reinforcements and incentives for attitudinal and behavioural norms changes of citizens, the government and business;

(ix) Cessation of small funds promised for the implementation of particular projects before the said projects are concluded.

The discussion in this paper is partly a result of a study conducted by researchers, where the author was a member, complemented by author's personal reflections and ideas from other literature sources.

2.0 METHODOLOGY

The country-wide air emissions from road traffic were estimated using one of the following two methods depending on their category:

- IPCC Workbook and methodology for greenhouse gases (IPCC, 2006); and
- Stockholm Environmental Institute (SEI) Workbook and methodology for non-greenhouse gases (Hippel and Vallack, 2006).

In this paper, only IPCC Workbook method was used.

The annual aggregate number of registered private vehicles was obtained from the Tanzania revenue Authority (TRA) where data from the Tanzania Bureau of Statistics was either considered doubtful or was lacking. Data for Government registered vehicles could not be obtained from the relevant authorities and assumed to 15% of all registered private vehicles. Since it was also not possible to obtain the number of cars registered in Dar es Salaam, it was assumed that **45**% of all registered vehicles remain in Dar es Salaam. This value was used to estimate air emissions in Dar es Salaam assuming 1-to-1 relations with the national data. The author is fully aware that this would not give accurate estimates; however the interest was mainly on the *trend* rather than on the accuracy of the figure, in order to allow some discussions.

Further assumptions made:

(i) To arrive at the air pollution figures shown, it was assumed that there is no control in the air pollution estimation equation and thus the basic equation for emission estimation is:

$$E = R \times \frac{EF(uncontrolled)x(100-C)}{100} \quad \text{……………………………..……….…...….(1)}$$

Where:
E = emission estimate for the process
R = activity level such as throughput
EF = emission factor assuming no control
C = capture efficiency x control efficiency (expressed in percent);
C = 0 if no control device is in place.

(ii) Emission factor developed by COPERT III software (Chariton and Zissis, 2000) and those recommended by the OECD (1995) were used (Table 3).

Table 3: Emission factors for air pollutants by fuel and vehicle type (Gg/PJ)

Sector specific data by fuel and vehicle types	CO_2	CH_4	N_2O	PM_{10}	CO	NO_x	NH_3	NMVOC
	G	**H**	**I**	**J**	**K**	**L**	**M**	**N**
Gasoline								
Automobile	69.30	0.031	0.0009	0.064	21.16	1.74	0.002	2.78
Light duty trucks	69.30	0.057	0.0009	0.110	58.00	2.52	0.002	2.47
Heavy duty trucks	69.30	0.021	0.0005	0.300	22.51	4.50	0.002	7.00
Motorcycle	69.30	0.130	0.0009	0.050	32.04	0.03	0.002	10.71
Gasoil								
Automobile	73.30	0.001	0.0019	0.150	0.75	0.58	0.001	0.18
Light duty trucks	73.30	0.001	0.0019	0.250	1.22	2.19	0.001	0.14
Heavy duty trucks	73.30	0.010	0.0019	1.000	3.40	13.41	0.003	1.95
Locomotive	73.30	0.006	0.0020	n.a	0.61	1.8	n.a	0.13
Boat & Schooners	73.30	0.005	0.0020	n.a	0.5	1.6	n.a	0.11
Jet A1	71.50	0.002	0.0020	n.a	0.12	0.29	n.a	0.018

Source: OECD (1995); Chariton and Zissis (2000): *COPERT III software*

(iii) Emission factors used for the calculations were based on the assumed 25°C temperatures with diurnals ranging from 28°C to 32°C, Reid Vapour Pressure of gasoline at 9 psi (62 kpa) and an *average speed* of 31.4 km/h, for typical near-congested urban driving (CEEST, 1997). The values are higher when traffic is congested and slow-moving and thus would lead to higher emissions according to equation 1.

3.0 RESULTS

CO_2 and CO values obtained from the estimations were tabulated as indicated in Table 4 where they are compared with other results CEEST[3] (2008) obtained by measurements using the Dragger Tube method (http://www.afcintl.com/).

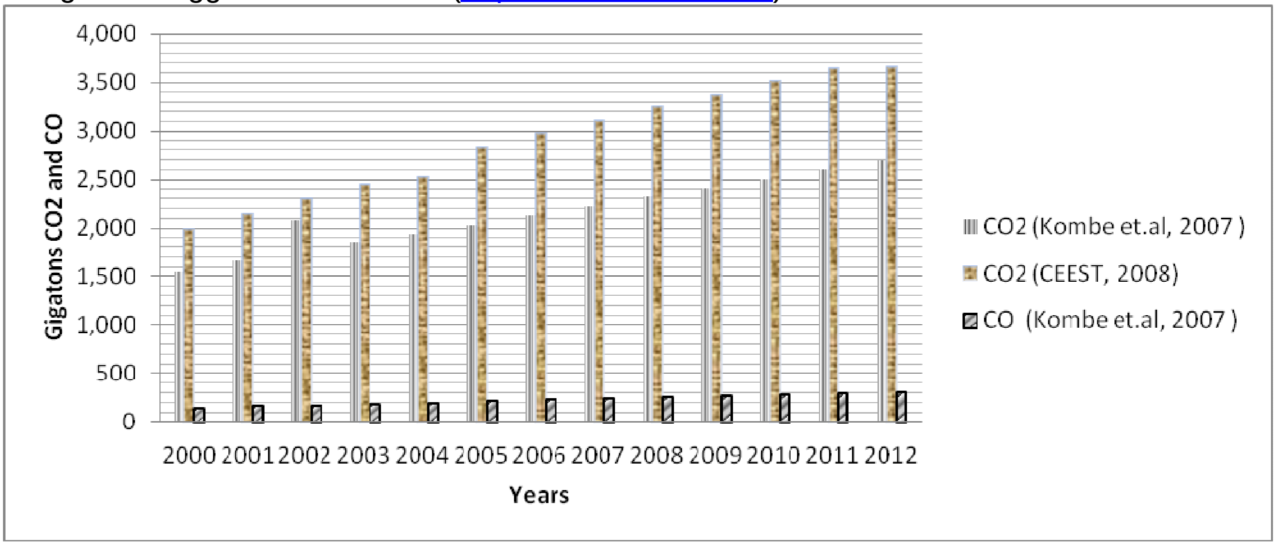

Fig. 13: Estimated CO2 and CO emissions in Tanzania: 2000 - 2012

Values from 2005-2012 were not available and were therefore calculated by the author based on the observed average trend for the available estimated figure for the five years (2000-2005); n.m = Not estimated.

Fig 13 indicates that over a period of 12 years (2000-2012), CO_2 increased by about 86,000-tons while CO increased by about 13,000 tons every year. The increase is expected from Table 2 which shows an increasing number of vehicles (as economic ability increased). Since these are national averages, the concentration values for the city of Dar es Salaam and other big cities will be expected to be much higher than the national average values since the cities have higher numbers of cars per capital, higher traffic congestion as well as compactness of the dwellings.

[3] CEEST = Centre foe Energy, Environment, Science and Technology

Table 4 shows CO and CO_2 concentration values measured at different times and at different city locations by other authors.

Table 4: CO and CO_2 values at four monitoring stations *in Dar es Salaam*

Monitoring stations	Pollutants (µg/m^3), (8-hr Average)				
	[1]CO	[2]CO	[3]CO	[2]CO	
Kariakoo	60-94	-	-	5,277.6	
Samora/Mgoro rd	94	-	-	5,286.2	
Magomeni	60-94	-	1.81	-	
Tandika		5.8	1.16	-	
WHO Guidelines	60	0.365	0.10	No guideline	No guideline

[1] = Kishimba and Othman (1993); [2] = CEEST (1996); [3] = Levina (2008)

As can be observed from the table, although the CO and CO_2 measured concentration values are on the high side compared to required standards (WHO) and most likely attributed to traffic congestion in the city, they can not be easily compared to enable drawing up any meaningful conclusion, which suggests a need for more work on this area with an aim to collect more data.

4.0 DISCUSSION AND RECOMMENDATIONS

A study has been conducted on the traffic congestion in Dar es Salaam city roads. Although the insufficient and rather limited data was obtained and used in the study, the results gave a hint that the Dar es Salaam roads are congested and polluted with the CO and CO_2 emissions which are on the high side and tend to increase with the increasing fleet and use of cars. The results further suggest that the emissions were increasing with the traffic congestion.

Traffic congestion is therefore undesired because it affects smooth traffic flow on the city trunk, regional as well as district and feeder roads including: Morogoro road, Mandela road, Kilwa road, Alli Hassan road, Nelson Mandela road, Chang'ombe/Temeke road, Nyerere road, Kawawa road and Bagamoyo roads leading to social, economic and environmental problems.

A number of factors and reasons have been suggested to cause traffic congestion and air pollution emissions problems in the city.

Traffic decongestion and thus reduction of emissions can be achieved either by increasing the road network capacity (supply) or by reducing traffic (demand) or both.

The following suggestions are made to address the identified causes for the traffic congestion and air emission problems in Dar es Salaam.

(i) The current city design and land use (largely Fig. 3-4) leads to unnecessarily long travel routes that require motorised transport, congestion, high transport energy use and high air pollution levels. Slight redesign of the city (Fig. 5-6) to introduce equal opportunities for sufficient social services at the city outskirts of the three city districts (Bunju and Kimamba in Kinondoni district, Pugu in Ilala districts and Kongowe and Kimbiji in Temeke district) as available at the city centre will ensure easy reach of social services, less need for long travel distances that require motorised transp. At the same time an idea to upgrade Kigamboni and the upgraded social service centres into satellite cities can be considered and pursued as a parallel strategy.

(ii) The road network including car parks, drainages and storm water facilities in Dar es Salaam city remain inadequate. The ongoing efforts by the Government to expand and improve the infrastructure in phases are commended.

- However, the expansions and improvements should consider parallel improvements of the existing adjustable lanes where additional town-wards lanes are availed in the morning and the other way round to accommodate more traffic in the evening peak hours.
- The redesign of the city roads (which is ongoing) is in addition constructing *over-pass* (fly-overs) and will hopefully also construct *under-pass* (driving under) as well as *road shoulders* on some of the cross-roads and other areas considered to be *critical bottle-necks* in causing traffic congestion. It is at the critical points where traffic congestion and air pollution occurs. While this is a commendable action by the Government it done with a focus of up to and beyond 50 years to ensure that adequate city transport system for the current and future generations is available.
- The redesign of the city roads should also go hand in hand with the construction with the construction and expansion of the non-motorised transport with provision of simple and basic amenities such as walkways, safe bikeways for pedestrians and bicyclists on most parts of the city roads. Construction/expansion of side ditches /drainages and sewer systems to reduce the hassle caused by rain to traffic during heavy down-pours should also be undertaken.

(iii) Requirement of motorized travel occurs if the distance between origin and destination is longer than walking distance. Moreover, the absence of a convenient and adequate public transport system will increase the propensity of users to opt private vehicles. It is high time now that the Government seriously improve public and mass transport systems in terms of their total numbers, capacity and convenience including reliability and other customer valued factors. *The DART*[4] is

[4] DART = Dar es Salaam Rapid Transport (An ongoing project to introduce fast high quality, low cost buses in the city with sufficient incentives to replace private vehicles) also known as BRT = Bus Rapid Transport

one of the strategies in the right direction but based on the expanding city population statistics, it is highly unlikely that DART will alone be able to solve the problem in the long run. On the other hand, the speed at which the DART project is being implemented is worryingly slow. *City trains* (trams) and other forms of mass transport (city-wide and country-wide) will be required. The trains and other public and mass transport systems should be convenient and of good standards comparable to those available in developed countries so that users will be convinced to forego other private transport means and use them. The advantage of this alternative is that there is already basic railway infrastructure in place for the start; what will be required is to improve, strengthen and expand the railway infrastructure (city-wide and country-wide) in place. Another advantage of this suggestion is that it does not compete with the roads, it has a very high capacity, lower total air pollution loads and is more costs effective than the road transport system.

(iv) The current restrictive urban growth policies aimed at reducing the rate of rural-urban migration appear to have had rather limited success in Tanzania and for Dar es Salaam in particular and will require revision for their strengthening so that they will address and be directed more towards transformation of the rural economy as an incentive for slowing down the rate of urban sprawl.

(v) Sensitize attitudinal and behavioural changes at individual level including car-pooling so that everybody is more corporately socially responsible.

(vi) Strengthen and enforce policies and legislation on old and dilapidated vehicles on the city roads and revisit practice on management of large and heavy vehicles in the city.

(vii) Revive and improve company/government common transport and prioritize funding and mitigation measures for traffic decongestion strategies.

(viii) Improve and strengthen road toll pricing such that differential tolls may be levied depending on whether or not it is peak hours and the type of vehicle – whether private or public etc. However, in spite of the many advantages of the suggestion, it will require careful planning and implementation in order to avoid congestion caused by the road toll stations.

5.0 ENCOUNTERED CHALLENGES

The study was confronted with a number of challenges including the following:

(i) It was very difficult to get timely and accurate data from the relevant authorities. At times there were unnecessary restrictions to avail data and, or conflicting data was obtained. In most cases there were gross delays in obtaining data or no data was availed by the relevant authorities;

(ii) It was also clear that in some cases, the data required did not exist. This is a challenge for the academic and other relevant institutions to initiate studies aimed at collecting data and expanding the national data storehouse which at the moment remain wanting.

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TRAFFIC CONGESTION IN DAR ES SALAAM CITY: THE PHYSICAL PLANNING PERSPECTIVE

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ABSTRACT

Traffic congestion, which is attributed by a number of factors including city structure, inadequate and poor road infrastructure, population increase, lack of plan to control city development, and rapid increase in number of cars is one of the major problems facing Dar es Salaam City due to a number The city is already implementing a number of projects in order to minimize traffic congestion. However, many of the current projects for reducing congestion in Dar es Salaam are focusing on improving the roads in a number of ways such making them wider, proposing new ring roads and flyovers. Widening roads, constructing new ring roads and flyovers cannot fully overcome the congestion problems in Dar es Salaam on its own unless these efforts are supported by redistribution of services and community infrastructure. Redistribution of services and community infrastructure, which can be achieved through physical planning, has the potential to minimizing traffic volume and travel distances. Therefore in order to overcome traffic congestion in the city the technical engineering solutions for road improvement should be applied together with physical planning solutions.

Key words: *Traffic congestion, city structure, poor road conditions, population increase, increase in cars and physical planning.*

1.0 GENERAL BACKGROUND

Dar es Salaam is the commercial city and main port of Tanzania, which was established in 1862 as a trading port is located along the East African Coast bordering the Indian Ocean. The city is hot and humid throughout the year with an average temperature of 29^0 C and maximum and minimum temperatures of 35^0C and 25^0C respectively (UN Habitat; 2008; Pan-African START Secretariat *et. al.,* 2011). Dar es Salaam has a bimodal rainfall system receiving about 1000 to 1300mm per annual. Topographically, the city can be divided into three main terrain units of lowlands found along Indian Ocean shores and river valleys, the middle plateau and the hilly areas found in the north and west of the city. Four main river systems of Mpiji, Msimbazi, Kizinga and Mzinga cut across the city (NEMC, 2009). The urban structure of the Dar es salaam is mono-centric as it has only one Central Business District (CBD) comprising of the city center and Karikoo area. The major urban functions and activities are concentrated in the CBD and along the major arterial roads.

Overall the Dar es Salaam can be characterized as sprawling low rise city that is not intensively built. It occupies a total of 1691.6 square kms out of this only 21.7 is a built-up area and the rest that is 78.3 per cent is sparsely built or covered by either natural or semi-natural vegetation or agriculture lands mostly in peri-urban areas. The main land uses in the built-up area are residential 13.2 percent, river/water body 4 per cent, industry 1.3%, other land uses including government institutions 3.2 per cent. Figure 1 shows the main land uses in Dar es Salaam (JICA, 2008). The residential houses in Dar es Salaam are dominated by single storey houses both in planned and in unplanned areas.

It is estimated that currently Dar es Salaam has population of 4 million people out of which about 60 per cent are employed in the informal sector. The main income generating activities in the informal sector includes petty trading, urban agriculture, fishing, and technical jobs such as mechanics, caperntry, masonry, plumbing and tailoring (Nnkya and Lupala, 2010. Pan-African START Secretariat *et. al.* 2011). About 65 to 70 per cent of the residents in |Dar es Salaam live in unplanned or squatter areas. Compared to population densities of many other cities, despite of its large population the city has a low population density of an average of 15 persons/ha. However, there are some areas especially those near the city center and some unplanned settlements that have 300 and 533 persons per hectare (Lupala and Kiunsi, 2011).

2.0 PHYSICAL PLANNING

Physical planning also known by a variety of other names including town planning, urban and regional planning or urban planning deals with spatial arrangement of land uses in urban or rural settlements. Through physical planning, spatial development plans of settlements, commonly known as master plans are prepared. The master plans do indicate the arrangements of different land use types including for residential, commercial, institutional, open areas, recreational and line infrastructures such as transportation facilities in an urban area. Master plans have been prepared and used for the guidance of a number of urban areas in Tanzania including Dar es Salaam. The last master plan for Dar es Salaam was approved by MLHHSD in 1979 covering a period of 20 years. Currently the city does not have updated master plan. In 1992 the Government through the City council introduced a new planning approach called Environmental Management Plan (EMP) in order to address the problems that arose due to lack of updated master plan. The main objectives of EMP among other things was to increase the capacity of the city council to manage urban growth and development through participatory approaches of the communities, NGOs, central and local government and private sector. EMP was successful in identifying specific environmental issues and in developing squatter upgrading programmes but failed to deliver long term vision and comprehensive policies and guidelines for urban growth. Consequently, MLHHSD is now preparing a new master plan for Dar es Salaam.

3.0 ROADS AND TRAFFIC IN DAR ES SALAAM CITY

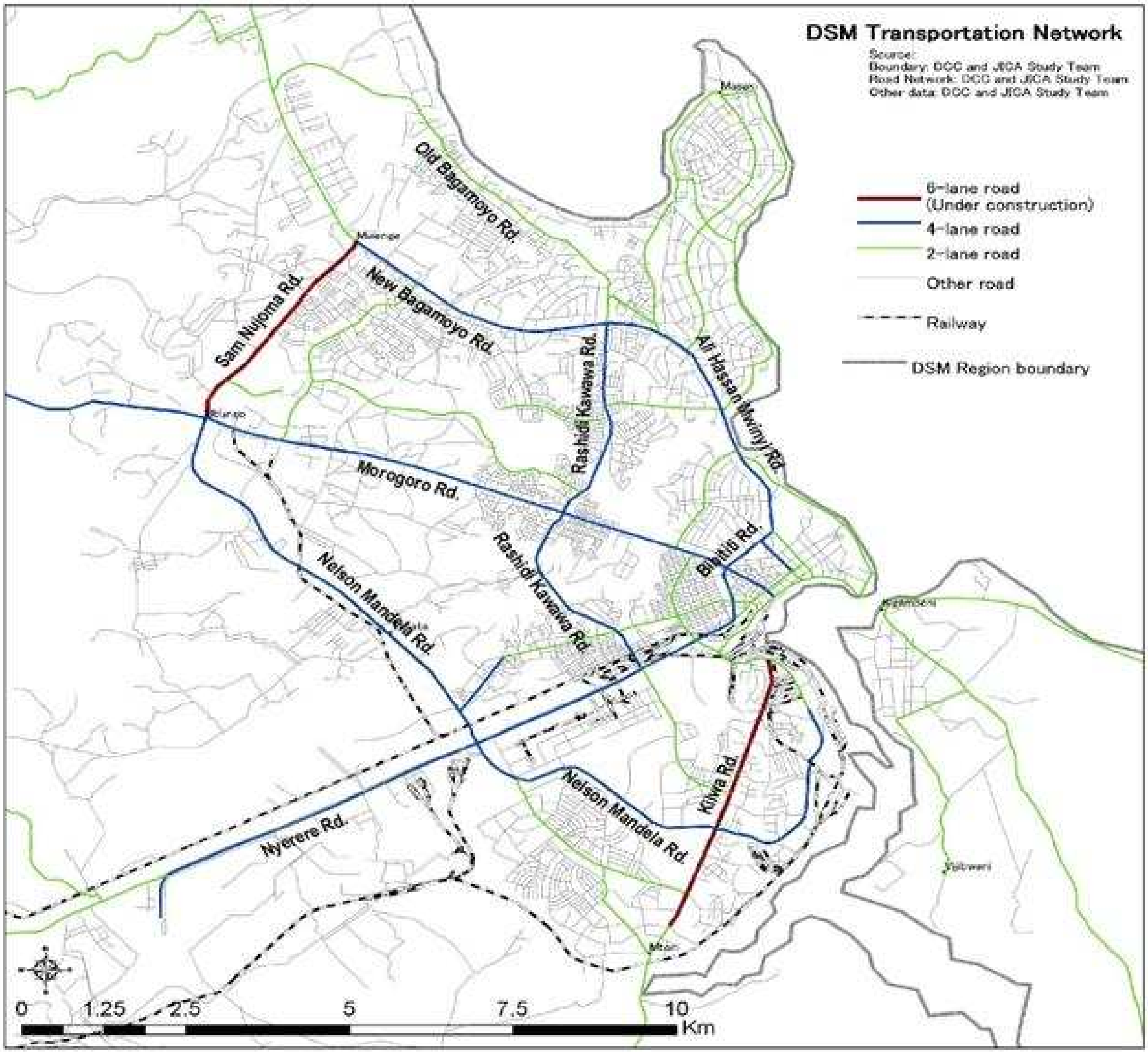
Dar es Salaam City development is partly influenced by the arterial road network consisting of five main radial roads and one ring road all terminating in the CBD. The five radial roads are Kilwa Road, Nyerere Road, Morogoro Road and New and Old Bagamoyo Roads and the main ring road is the Mandela Road. The total length of roads based on 2005 data is about 1717 km out of which 395 or 23 per cent are paved (JICA, 2007). Figure 1 shows the main roads in the city. The roads that are paved in Dar es Salaam are mainly the arterial roads. The distribution roads in many of the residential and commercial areas are not only not paved but poorly maintained. Table 1 shows the length of roads in three municipals of Dar es Salaam. In general it can be said that roads in Dar es Salaam are not only poorly maintained but also they are inadequate to cope with travel demand as it overall land coverage is only 2.5 per cent compared with standard requirement of 15-20 per cent.

Table 1: Road distribution within Dar es salaam City

Municipality	Paved Road (km)	Unpaved Road			Total (km)
		Gravel (km)	Earth (km)	Total (km)	
Kinondoni	180(32.5%)	162	211	373	746
Ilala	139(26.1%)	63	330	393	786
Temeke	76(12.0%)	256	300	556	1112
Total	394.294(23%)	481	841	1,322 (77%)	1,717

Source JICA (2007)

In recent years there has been a rapid increase in importation of different types of cars in the country as reflected by Tanzania revenue Authority (TRA) registration records. Based on the TRA records between 2003 and 2010 a total of 917 723 cars were registered by the authority. It is estimated that about 60 to 70 per cent or between 550,000 to 640,000 cars are plying in Dar es Salaam roads. As in other parts of the world Dar es Salaam has a mixture of different types of vehicles including cars, trucks, buses and other types of vehicles such as motorcycles. JICA traffic survey results of (2007) showed the composite vehicle mix in Dar es Salaam for areas within and beyond Nelson Mandela Road corridor. The results showed that within the Mandela Road Corridor the vehicle composed was dominated by cars including taxis (55 per cent), trucks including pickups (23 percent) buses including daladala (13 per cent) and others including motorcycles 9 per cent. However the picture was different outside the Nelson Mandela corridor as trucks dominated by 37 per cent.



Traffic congestion is one of the major problems affecting Dar es Salaam city. A number of studies, including JICA travel speed that was conducted in 2007, have been done to establish the extent of traffic congestion in the city. As per JICA study traffic congestion is more serious in some sections of major the arterial roads such as Morogoro, Kilwa, Nyerere, Mandela, Rashidi Kawawa and Ali Hassani Mwinyi Roads to mainly due to very low speed at road intersections especially during the peak hours. The following is a brief explanation of road sections that are most congested. In the Morogoro Road at Ubungo intersection traffic congestion can take more than 15 minutes while at Magomeni there is traffic congestion all the day and sometimes it takes up to 20 minutes and at Bibi Titi Mohamed there is traffic congestion all day. Along Nyerere Road there is traffic congestion at Tazara intersection that can take more than 25 minutes and at Chang'ombe and Msimbazi intersections. On the Hassan Mwinyi Road traffic congestion occurs at the UN, Kinondoni, Old Bagamoyo and at Mwenge intercections. Along the Nelson Mandela Road Traffic congestion occurs at Tabata and Buguruni intersection. Appendix 1 to 4.show the most affected sections or points of the roads during the peak hours of the morning and evening and off-peak hours.

Traffic congestion has socio-economic and environmental impacts to the city dwellers and the city itself. At an individual level it is an economic and social burden as it not only adds transportation costs but it also it takes up time that could have been used for other social and economic activities. This can negatively affect the well being of a family. At the city level traffic congestion affects the economy of the city as it increases the costs for conducting business and contributes to climate change due to generation of more Green House Gases (GHG).

5.0 FACTORS CONTRIBUTING TO TRAFFIC CONGESTION

There are number of factors that are contributing to traffic problems in the city including city structure, population increase, lack of overall plan to guide city development, rapid increase in car numbers and inadequate an poor road conditions. Each contributing factor is briefly discussed below.

5.1 Mono centric city structure

As already indicated Dar es Salaam City has got only one CBD with the arterial road originating from it. This means that a lot of city services and institutions are located at one major point. This has led to traffic to predominantly to flow from residential areas to the CBD in the mornings and vice versa in the evenings. The predominantly one direction flow of traffic contributes to congestion in the mornings and evenings along the main roads and intersections (Kiunsi, *et. al.* 2006; Lupala and Kiunsi 2011).

5.2 Urban sprawl

The urban sprawl of Dar es Salaam means that the city authorities are forced to provide infrastructure and other social services including transportation services to unnecessarily large area. However, authorities cannot adequately cover the whole city as they have limited resources. The end result of urban sprawl in Dar es Salaam is the poor and inadequate provision of service infrastructure including roads. In addition to poor service provision urban sprawl forces urban dwellers to use motorized transport to travel long distances to other parts of the city to obtain different kinds of services. The two factors of poor road infrastructure and the necessity to use motorized transport contributes to congestion in the city.

5.3 Population increase

As already pointed out about 4 million people, equivalent to 10 percent of the urban population in the country are living in Dar es Salaam. The city is growing at a very fast rate as reflected by the increase its population from 0.85 million in 1978 to 1.36 in 1988, to 2.49 in 2002 and to 4 million in 2007. The current growth rate is estimated to be 8 per cent per annum compared to 9.7 per cent (1967-1978), 4.8 per cent (1978-1988) and 4.4 percent

(1988-2002). The growth rate of Dar es Salaam is one of the highest in Sub Sahara Africa. As a result of this the city cannot provide adequate services and infrastructure including transportation infrastructure to cope with population increase and therefore, contributing to traffic congestion. As a matter of fact Dar es Salaam will become a mega city within the coming 25 years. This will have very serious implication on provision of public services including transport. Figure 2 Shows the trend of population growth in the city.

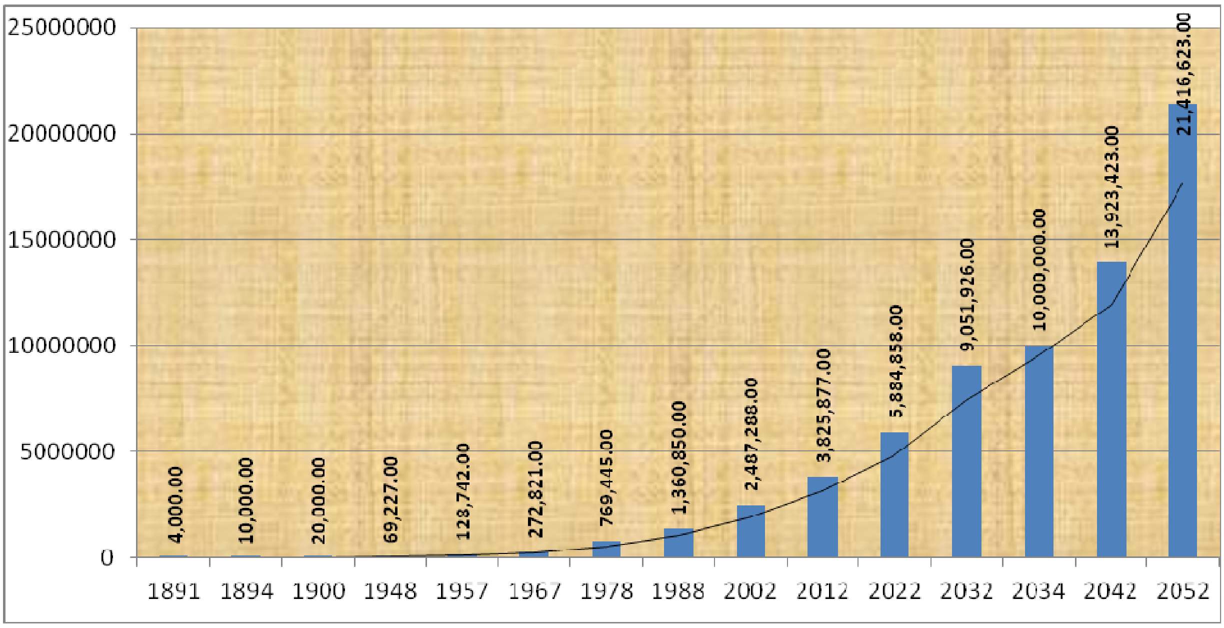


Figure 2: Trends of population growth for the Dar es Salaam city
Source: Lupala and Kiunsi (2011)

5.4 Lack of adequate and overall plan and development control to guide city development

The first master plan for Dar es Salaam City, after independence, was made in 1968 and the second one in 1979 covering a period of 20 years up to 1999. Since then Dar es Salaam has not had an overall plan to guide its development. The 1979 master plan was not reviewed during the whole period of its existence apart from the City Council in 1992 introducing the Environmental Management Plan (EMP). Apart from not being revised the 1979 master plan was to a large extent not implemented as planned. In other words there was a very poor development control during the existence of the second master plan. The concept used to develop the master plan was good and if it was fully implemented it could have indeed contributed to the reduction of current traffic congestion in the city. The master plan proposed the city to be structured with six main levels of ten cell, housing cluster, neighbourhood, community and district the level. At each level appropriate services and community facilities could be provided. Table 2 shows the types of facilities and services that were to be provided at each level. The type of services and their capacity were planned to increase as you go up the city structure. As an example at housing cluster level only a nursery school and paying ground were to be provided level. While at the district level a higher order of facilities and services including commercial, office space and recreational areas. The aim of the urban structure was to ensure adequate distribution of facilities within the city that were within easy reach of all residents.

Table 2: City structure as proposed in 1979 master plan

S/N	Level	Size	Services
1	Ten cell unit		
2	Housing cluster	10 ten cell units (100 plots)	Nursery school, 2 play grounds
3	Neighbourhood	Four to eighty housing clusters (5000 people)	• Primary school with associated playing grounds, • one local market and few small shops • One recreation area
4	Community	Eight neighbourhoods (40,000 people)	• One major market and shopping area • One community hall • Two religious sites • Two major recreational areas
5	District	200,000 to 300,000 people	• Commercial component o Public and private office space o Wholesale and retail shopping facilities o Petrol service facilities • Apartment units • Institution component o District hospital o Fire protection services o Secondary school • Recreational component o A small exhibition area o A major recreational facility including playing fields, athletics tracks, practice fields, restaurants, offices, parking space and open space

Ministry of Lands, Housing and Urban Development (1979)

The master plans clearly did point out that such urban structure would reduce the daily need to travel to the city center for common services. Unfortunately, this was not fully implemented as evidenced by many large residential areas in Dar es Salaam not having basic facilities and services. Consequently, their residents in these areas have to travel regularly to the CBD to obtain such services and therefore contributing to more congestion.

5.5 Rapid increase in number of cars

In the recent years there has been a rapid increase in a number of imported cars in Tanzania due to a number of factors including increase in population and increase in incomes of the city dwellers, removal of restrictions on importation of cars and easy credit for buying cars. The number of cars in the city has increased from 24,600 in 1979 to

640,000 currently Marshal and (Macklin Monaghan Ltd, 1979). The increase in the number of vehicles has further increased traffic congestion in the city.

Inadequate and poor road infrastructure.

5.6 Other contributing factors

The other contributing factors to traffic congestion are inadequate and poor road conditions, poor public transport and inadequate parking facilities. The Dar es Salaam roads are inadequate because they are few and they cover only 2.5 per cent of land in Dar Salaam instead of 15 to 20 per cent as urban planning standards. The public transport is poor due low quality of services provided by the Daladala, spatially limited operational coverage, lack of fixed time schedule and long waiting hours at the bus stops. This makes a number of city dwellers who have cars to opt to use private vehicles instead of the public transport. In addition Dar es Salaam has only one main mode of public transport, the buses. This is now inadequate due to the size of the city, especially as the city is expected to become a mega city within the coming 25 years. There is limited parking space especially in the CBD this forces some people to park in road sides, making the roads even much narrower. All these factors exacerbate the traffic congestion problems in the city.

6.0 DECONGESTING DAR ES SALAAM

Traffic congestion in the city can be reduced by using three main approaches by improving road infrastructure, reconfiguring community services and infrastructure and improving public transport.

6.1 Improving road infrastructure

The improvement of road infrastructure has two main elements, firstly, the improvement of the existing roads so as to improve traffic flow in the city. This entails expanding the roads, building flyovers at road intersections, constructing ring roads and paving the distribution and access roads in the neighbourhoods. The Government and the City Council is already working on this issue. Examples for roads earmarked for improvement include Ali Hassani Mwinyi and Wazo Hill and Mbezi Luis Ring road and the intersection of Ubungo and Tazara. Secondly, as already pointed out road coverage in Dar es Salaam is only 2.5 percent compared with between 15 to 20 percent that is required. Therefore there is a need for planning and building up of new roads including ring roads and flyovers.

6.2 Redistributing community services and infrastructure

Redistribution of services and infrastructure should aim at bringing the services within the easy reach of Dar es Salaam residents so as to minimize traffic volume and travel distances. This can be achieved through physical planning and will completely change the traffic flow in the city. This means preparing plans that will create new satellite towns and also identify large residential areas where essential services will be improved. In essence it means revisiting the 1979 master plan ideas on the urban structure and associated facilities. The provision of required facilities in the already existing neighbourhoods will not be easy as it will likely lead to demolition of existing properties in order to make room to services in demand. This exercise can also lead to the densification of the city as high rising buildings will be constructed in areas earmarked for service provision. Areas that can be considers for this exercise include Bunju, Mbezi Luis, Kongowe and Pugu kajiungeni. In the context of satellite towns the Government and the City Council have already identified Luguruni as a potential area.

6.3 Improving public transport

Public transport needs to be improved so as to make it more attractive to the city residents, which can lead to the reduction of the use of private cars. This can be done by firstly, improving the existing bus services by introducing buses that have a bigger capacity in areas that have high population density. This is already being done through the introduction of Rapid Bus Transport. Secondly, introducing and enforcing time schedule for all large buses using Dar es Salaam main roads. Thirdly, controlling the overcrowding and behavior of daladala workers so as to bring discipline and harmony in the buses. Lastly, introducing new modes of public transport in the city including mass transport systems. The mass transport systems to be considered are trains that can use the existing railway lines in the city. Trains can ferry city dwellers from example Ukonga or Ubungo to the city center. The marine ferries can be plying between the city suburbs in the north along the Indian Ocean and the Dar es salaam harbor. The ferry trips can start from Bagamoyo and Ununio, White Sands hotel, Kunduchi, Africana, Kawe, to Dar es Salaam harbor. In order for this strategy to work ferry landing sites and parking areas and public transport stations needs to be developed.

7.0 CONCLUDING REMARKS

Traffic congestion is indeed a serious problem in the city that has numerous socio-economic and environmental impacts. Congestion in Dar es Salaam is caused by a number of factors including poor distribution of service and community infrastructure that has led traffic flowing predominantly in one direction during the morning and evening peak hours. The city is already implementing a number of projects including improving the road infrastructure and public transport to reduce the congestion. However, in order for the current solutions to work more effectively, the distribution of services and community infrastructure should also be done. The reconfiguring the services and infrastructure in the city can only achieved through physical planning interventions.

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TUMBLING THE IMPENETRABLE ROAD CONGESTION IN DAR ES SALAAM; A COMMUTER SERVICE PERSPECTIVE

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ABSTRACT

This paper examines the gravity of road traffic congestion problems in Dar es Salaam and proposes some feasible solutions considered necessary to decongest the city. Congestion occurs when transport demand exceeds transport supply at a specific point in time and in a specific section of the transport system where each vehicle impairs the mobility of others.

Road congestion in Dar es Salaam is characterized by public transport services that are provided by 6,000 licensed small capacities buses and 84.3% of buses have a carrying capacity of less than 30 commuters resulting into chaotic public transport compelling commuters to go for private cars.

Challenges associated with congestion include: millions of man-hours are lost as commuter buses and vehicles move at a snail's pace. Work in public and private sectors are not done in time thence affecting socio-economic development. Traffic jams consume tones of fuel bought by foreign currencies and emit pollutants.

This paper provides feasible solutions such as; adequate public transport capacity, corporate commuter service providers, heavy occupancy vehicles, alternative work schedules, commuter bus crew training, park and ride, parking management, road pricing, driver training, priority lanes, law enforcement and use of traffic lights if applied the City will be able to enjoy smooth flow of road traffic.

1.0 INTRODUCTION

Cities are locations having a high level of accumulation and concentration of economic activities and are complex spatial structures that are supported by transport systems. The most important transport problems are often related to urban areas and take place when transport systems, for a variety of reasons, cannot satisfy the numerous requirements of urban mobility. Congestion occurs when transport demand exceeds transport supply at a specific point in time and in a specific section of the transport system. Under such circumstances, each vehicle impairs the mobility of others.

If traffic flow exceeds the capacity of a road traditionally we tend to add additional lanes to reduce density and enhance the speed. This is the effect of traditional transport education. If density is decreased, the car transport becomes more attractive, more people use their cars, the speed is enhanced not only to local traffic and finally the same congestion appears, but this on a higher level. This is the inevitable outcome of traditional transport treatment methods.

Public run commuter service structures in Tanzania like in other developing economies had experienced demise through poor public sector management and a failure to satisfy market demand resulting in a decrease in publicly operated services. This has led to a corresponding increase in less-organized private operators who have filled the supply 'vacuum', as is the case with the daladala operators in Dar es Salaam, Matatu in Kenya.

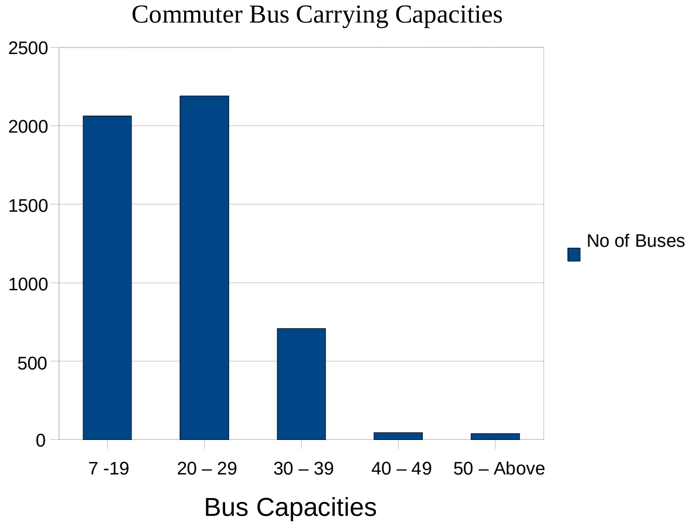
The population of the city which is about four million people mostly depends on public transport services for their travel within the City and a growth rate of 4.3% per annual as per 2002 census. The city has three municipalities of Ilala, Kinondoni and Temeke while having an area of about 1393 km^2. Public passenger transport service in Dar es Salaam city has for many years been unsatisfactory. It is generally poor and unsafe, lacking professionalism, efficiency and quality to commuters. The main factors leading to the above situation include; rapid expansion of the City which has far outpaced the capacity to provide basic infrastructure (such as good roads) and services, poor state of majority of the buses, untrained bus drivers and conductors driven by the pursuit of daily revenue targets payable to the bus owners, non-adherence to traffic rules and regulations and lack of an organized public transport system. The service offered is poor due to overloading in small carrying capacity and overcrowded buses particularly during peak hours, reckless driving, route shortening, harassment of women and schoolchildren and polluting vehicles particularly during peak hours dominated by traffic jams on all major roads in the City.

The commuter services in the city are currently provided by about 5,000 licensed small capacity privately owned buses, known as 'Daladalas' and by about 27 minibuses owned by a public company- "Shirika la Usafiri Dar es salaam (UDA)", DART (2010).

The land use pattern consists of one central area adjacent to the seashore, which is serving as a focal point where most of commercial, public and government institutions are located. The city is facing a serious problem of road congestion on the arterial road network and the Central Business District (CBD). Increasing population calls for increasing business and accommodation in the city centre, which in turn brings an increased traffic and parking demands and requirements. These increases were not taken into consideration by the transport and city planners during the planning stage, consequently, traffic jams and conflicts in Central Business Districts (CBD).The main cause of road traffic congestion is that the volume of traffic is too close to the maximum capacity of a road or network although there are other causes of road traffic congestion in the case of Dar es Salaam city.

Commuter buses licensed to operate in the city are of small carrying capacity; about eighty four percent (84.3 %) of buses have a carrying capacity of less than thirty commuters only as presented in figure 1. Moreover, there is an inventory of 3,171 commuter service operators in the city and only 27 operators are registered companies with the Business Registration and Licensing Authority DART, (2010).

Figure 1: Commuter Bus Carrying Capacities Distribution



There are many empirical studies on the estimation of values of travel time savings (VTTS), with varying degrees of objectivity and relevance, mostly based on the observation that travellers are prepared to spend money to save time. These values are applied to both forecasting the effects of speed changes on behavior and also for estimation of the social benefit of such savings, in order to calculate value for money of spending public funds on transport investments. A study conducted by ITDP (2009) revealed that cities with Bus Rapid Transit (BRT) are congested since the rapid speed range from 25-50km/hr as shown in table 1.

Table 1: Congested BRT Cities Speed

City	Country	Public Transport Speed(km/hr)
Guangzhou	China	25
Beijing	China	21
Seoul	South Korea	17
Brisbane	Australia	19
Bogota	Columbia	25
Jakarta	Indonesia	21
Curitiba	Brazil	22
Sao Paul	Brazil	16
Hangzhou	China	23
Average		21
Standard Deviation		3.202
Variance		10.25

Source: ITDP (2009)

From table 1 it implies that the congested BRT world is moving at a speed of 21km/hr with the dispersion of 3.202km/hr. This prompted the researchers to conduct the study on the level of congestion in Dar es Salaam City.

Basing on the fact mentioned above, the study was conducted to determine the gravity of commuter service road traffic congestion in travel time lost per trip to commuters and suggest ways that if deployed can remove completely the traffic jams problem in the city.

2.0 METHODOLOGY

The study selected the major arterial road network routes, which transverse from the CBD of the city to the densely populated sub urban centers for observation. The selected routes included; Kimara-Posta, Kimara-Kariakoo, Mwenge-Kariakoo, Mwenge-Posta, Airport-Posta, Gongolamboto- Posta and Tegeta-Kariakoo. Primary data was collected in these routes for a period of one month using a participatory observation technique. The data presented in table 2(a) as observed time represent an average observed travel time spent in a particular route for the month of August 2011 on working days only. The study findings were compared to the findings revealed in table 1.

3.0 DATA ANALYSIS

Data collected were analyzed using descriptive statistical data analysis. Measures of central tendency and dispersion were used to determine the level of dispersion. It measures how similar are the route speed to each other. Normally, the more similar the speed is to each other, the lower the measure of dispersion will be. The less similar the speeds are to each other, the higher the measure of dispersion will be. In general, the more spread out a distribution is, the larger the measure of dispersion will be. The standard deviation was calculated using the following formula:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{x})^2}$$

Where,

σ = standard deviation,
x_i = each value of dataset,
$\overline{x}$ = the arithmetic mean of the speed
N = the total number of data points
$\sum (X_i - \overline{X})^2$ = The sum of $(X_i - \overline{X})^2$ for all data points

While the variance is calculated by the given formula:

$$\sigma^2 = \frac{\sum (X - \mu)^2}{N}$$

Where, μ = is the mean and N is the number of scores.

4.0 STUDY FINDINGS: GRAVITY OF COMMUTER TRAFFIC CONGESTION

Data collected were summarized and analyzed in table 2(a) and (b) below:

Table 2(a): Normal Traffic Flow Travel Time Analysis

Route	Distance (km)	Time for normal traffic flow (in minutes) @ 24 km/h	Observed time (August, 2011) in minutes	Delayed time	Delay for Round trip per day in minutes	Hours taken	Congestion speed Km/h
Kimara -Posta	16.4	41.0	115.0	74.0	148.0	1.917	8.557
Posta-Kimara	16.4	41.0	118.0	77.0	154.0	1.967	8.339
Kimara -Kariakoo	15.0	38.0	93.0	55.0	110.0	1.550	9.677
Kariakoo-Kimara	15.0	38.0	90.0	52.0	104.0	1.500	10.0
Mwenge-Kariakoo	10.3	25.8	42.0	16.2	32.4	0.7	14.714
Mwenge-Posta	11.9	30.0	45.0	15.0	30.0	0.75	15.9
Posta-Mwenge	11.9	30.0	53.0	23.0	46.0	0.883	13.472
Airport-Posta	11.0	27.0	51.0	24.0	48.0	0.85	12.941
Posta-Airport	11.0	27.0	43.0	16.0	32.0	0.717	15.349
Gongolamboto-Posta	17.0	43.0	72.0	29.0	58.0	1.2	14.167
Posta-Gongolamboto	17.0	43.0	84.0	41.0	82.0	1.4	12.143
Kariakoo-Tegeta	24.7	61.8	131.0	69.2	138.4	2.183	11.313
Tegeta - Kariakoo	24.7	61.8	125.0	63.2	126.4	2.083	11.856
						Average Speed	12.18
						SDEV	2.517
						VAR	6.334

From table 2(a) the average speed from all major routes studied was found to be 12.18km/hr, with standard deviation of 2.517km/hr and variance of 6.334km/hr. Comparing these results with that of table 1, the study findings from Dar es Salaam routes are similar to each other and has less dispersion in relation to congested BRT world cities. Therefore, this confirms that commuter routes in Dar es Salaam are at a speed of 12.18km/hr against the congested BRT world cities which are running at a speed of 21km/hr with the standard deviation of 3.2km/hr and variance of 10.25km/hr.

From these findings, Dar es Salaam is congested by 172% compared to congested BRT World Cities. Dar es Salaam commuter travel time is more by 72% than congested BRT world cities. The correlation coefficient can be studied to compare the economic growth rates of the respective cities.

Table 2(b): Rapid Traffic Flow Travel Time Analysis

Route	Distance (km)	Expected Time with Rapid Bus Flow = 30km/h	Observed time (August, 2011) in minutes	Time difference @ 30 km/h
Kimara -Posta	16.4	32.8	115.0	82.2
Posta-Kimara	16.4	32.8	118.0	85.2
Kimara -Kariakoo	15	30	93.0	63.0
Kariakoo-Kimara	15	30	90.0	60.0
Mwenge-Kariakoo	10.3	20.6	42.0	21.4
Mwenge-Posta	11.9	23.8	45.0	21.2
Posta-Mwenge	11.9	23.8	53.0	29.2
Airport-Posta	11	22	51.0	29.0
Posta-Airport	11	22	43.0	21.0
Gongolamboto-Posta	17	34	72.0	38.0
Posta-Gongolamboto	17	34	84.0	50.0
Kariakoo-Tegeta	24.7	49.4	131.0	81.6
Tegeta - Kariakoo	24.7	49.4	125.0	75.6

Source: Field survey August 2011

From table 2(b) the problem is even bigger as Dar es Salaam commuter travel time is compared to uncongested Bus Rapid Speed (25-50km/hr). The delayed time per trip when compared to rapid speed, range from 21 minutes (Posta- Airport) to 85.2 minutes (Posta-Kimara).

The perceived impacts of congestion as part of the qualitative findings from group discussions we held with bus drivers in all routes of the city includes:

a) Driving found to be harder or more tiring
b) Increased risk of accidents or mishaps
c) Increased fuel consumption
d) Major source of driver stress – making many respondents feeling frustrated, angry, anxious, confused and exhausted.

Also from the group discussions with bus drivers, the following were deduced to be the causes of commuter road traffic congestion in the city; inadequate public transport capacity, private commuter bus owned, untrained drivers, unfriendly commuter bus services, no priority bus lanes, centralization of public offices in the CBD, no public transit, damped working hours, un-working traffic lights, no separate pedestrians and cyclist tracks, accidents and poor freight distribution systems.

5.0 RECOMMENDED WAYS TO TUMBLE COMMUTER TRAFFIC CONGESTION IN THE CITY

(i) Adequate public transport capacity: According to Tanzania Investment Act of 1997;

- If wholly owned by a foreign investor or of a joint venture, the minimum investment capital is not less than Tanzania Shillings equivalent of US dollars three hundred (US $ 300,000)
- If locally owned, the minimum investment capital is not less than Tanzania Shillings equivalent of US dollars One hundred thousand (US $100, 000)

The transport sector is partially included in the priority sectors. For instance while trucks enjoy tax relief as capital goods under this law buses do not. Consequently the commuter service investors are discouraged to make meaningful investment. This situation has negative impact in commuter service capacity in the city, which requires heavy investments in buses and related equipment. The Act should therefore be reviewed to include buses and related equipment into the capital goods incentive package to attract potential investors in the commuter services.

(ii) Corporate commuter service providers; The current bus owners providing commuter services in Dar es Salaam are advised to form companies under the companies Act no. 12 of 2002. This will reduce the number of operators and enhance professionalism and regulatory. Companies to be formed will be able to borrow capital from banks and train their staff to the required standards. It will ease the management of the well trained staff and effect contractual employment of commuter bus crews. In managing company growth it will be possible for them to get into Joint Ventures so as to meet the market demand professionally.

(iii) Commuter bus crews training; all stakeholders responsible in commuter service provision should pay attention to commuter bus crew trainings.Crews should be trained on how to handle commuters (customer service). This will enhance confortability of commuter services in Dar es Salaam and attract private car users to use commuter services. Well trained drivers will drive properly on city roads.

(iv) High Occupancy Vehicles (HOV); HOV lanes greatly shorten commute times by reducing the volume of traffic. They significantly reduce congestion delays both to people who shift mode and those who continue driving.

(v) Alternate working hours; encouraging work hours other than the dominant 8 to 4 schedule. One of the causes to traffic congestion in the city is damped working hours. This result into commuter service demand concentrated in two main peak periods of two hours each. Efforts have been made to meet this demand by increasing road capacity, which has never been sufficient and has resulted in an under use of the capacity in the other 20 hours each day. For example the CBD shops can be opened at 10.00 a.m and being closed at 08.00 p.m.

(vi) Unfriendly commuter bus services (abusive language, dirtiness, worn-out vehicles buses); the current environment of commuter services in the city makes it acceptable only to low income earners and/or to those who cannot travel otherwise. Commuter services operators have created unfriendly environment to their customers which has led to many people opt for private cars and resulting into current road traffic congestion. This behavior can be changed through training of drivers and conductors on how best they can offer their services.

(vii) Decentralization of public offices in the CBD; decentralization of public offices will reverse the current one direction movement of traffic towards the city center during peak hours. This can be done by locating the public offices in different parts especially at the outskirt of the city.

(viii) No priority bus lanes; there should be bus lanes on major routes and expressways that are reserved for buses, taxis and passenger vehicles with several occupants. The goal is to encourage use of buses and high occupancy vehicles that can be seen to travel at higher speed along the reserved lanes by other drivers who may be stuck in traffic jams.

(ix) Working traffic lights; Active traffic lights will reduce the rate of congestion in urban areas. For congested intersections, traffic lights should provide priority to decongest them and ease mobility in the city. In order to achieve this strategy, greater attention is required.

(x) Separate pedestrians and cyclist tracks; the city should promote and protect cycling as a means of urban transport. All major roads in Dar es Salaam should have physically protected cycle tracks, minor roads should have traffic calming measures (e.g. speed bumps) to protect and encourage walking and cycling, and workplaces should encourage employees to cycle and provide facilities (e.g. showering and cycle parking). In many areas of high population density, the quality of life (enhanced safety, less pollution etc) and the visual attractiveness of streetscapes can be enhanced by excluding vehicles from streets altogether, or limiting access to public transport vehicles. In Europe this has become a distinctive feature of the historic cores of many cities.

(xi) Freight distribution systems; restrict the movement of large (exceeding 10 tons) trucks on busy route, with high traffic, such as Bagamoyo, Morogoro, Nyerere and Mandela roads. The movement of the trucks should be allowed only outside of rush-hours, especially at night for beverages and sundries distribution in the city.

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A SURVEY OF THE IMPACT OF HUMAN FACTORS ON MITIGATING ROAD TRAFFIC CONGESTION AND FLOODS IN DAR ES SALAAM CITY

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ABSTRACT

Both road traffic congestion and floods in Dar es Salaam city are not only getting worse with time, but also the former worsens in the presence of the latter. Various strategies have been identified to mitigate the two problems and their implementation is at different stages. Since the two problems are closely linked to people's behaviour and/or activities, this paper presents a survey of the impact of human factors on the success of the present and future strategies. Physical surveys carried out in different parts of the city, coupled with available information from authorities responsible for managing the same, indicate that road traffic congestion is mainly caused by behaviour of drivers, road/vehicle conditions and limited traffic flow capacity. It is observed that improper use of roads and/or bus stands/road junctions are major components of all the sail causes. On the other hand, floods are caused mainly by restrictions in the natural flow of rain water into the ocean through human behaviour/activities. Natural valleys and man-made drainage systems are either blocked by buildings or clogged with soil/sand and all sorts of debris..

In mitigating both traffic and floods in the city, it recommended that;

- *both commuter buses and commuters should use the bus stand says on a First-In-First Out (FIFO) basis.*
- *both road and traffic rules/regulations should be enforced to ensure that driving/overtaking on road shoulders is prohibited because the practice leads to soil erosion which may cause floods and/or destroy the road carriage way.*
- *Natural valleys and man-made drainage systems for conveying rain water into the ocean should be cleared and kept clean by creating local environment groups under the supervision of local government units at the lowest level.*

1.0 INTRODUCTION

Generally, it is argued that road traffic congestion in most cities is caused by unmatched road capacity and vehicle supply, limited traffic flow capacity, road conditions and competition among drivers (Gakenheimer, 1997). However, a study carried out in Dar es Salaam city showed that the major causes for road traffic congestion are only three namely; behaviour of drivers/road users, road/vehicle conditions and limited traffic flow capacity (Bundara, 2010). Although one way argue that limited traffic flow capacity can be influenced by some natural causes, such a situation will only occur periodically like in the case of fog and floods. Otherwise both the general causes and those identified in the case of Dar es Salaam city are mostly influenced by human activities and, therefore, man-made. On the other hand, floods is a natural occurrence resulting from mainly rainfall/dam overflow water covering low lands or flow restricted areas. In other words, floods are both natural and man-made occurrences. Since Dar es Salaam is an ocean coastal city and the ocean is considered to be the lowest point on earth, rain water from all the high areas has to flow through the city into the ocean. This being the case, therefore, floods in the city will occur where the land surface is lower than the ocean level and/or where water flow into the ocean is restricted. When the city is flooded, the roads are covered by a large volume of water thereby restricting vehicle traffic flow. Incidentally, in Dar es Salaam city, this problem is worsening in every rainy season.

It should be noted that although man-made causes of both road traffic congestion and floods can be rectified by large capital investments, there is a need to identify the root source of the said causes in order to minimise costs and more importantly, prevent re-currency of the same. It is for this reason that the current author carried out a survey to shed some light on the impact of human factors in mitigating road traffic congestion and floods in Dar es Salaam city as presented next.

2.0 METHODOLOGY OF THE SURVEY

Two types of surveys were carried out. **First,** road traffic congestion trends in the city were monitored for a period of five years. This was done through driving own vehicle, travelling as passenger in public transport vehicles and walking on foot along congested roads. In every case, information was collected on;

- Number, type and causes of motor vehicle stops.
- Average speed of the vehicle queue on congested roads
- Season of the year (dry, short rains & long rains)
- Behaviour of drivers, road users and the general public in connection with road and vehicle use and maintenance.

Second, during the same five year period, the most flooded areas in the city were identified and their natural and built status physically inspected to establish the following parameters.

- Number, location and condition of natural valleys/rivers enabling water flow into the ocean.
- Availability and condition of water drainage systems.
- Number and condition of actual rain water discharge points into the ocean.
- People’s attitude and conduct towards provision and maintenance of drainage systems.

3.0 FINDINGS OF THE SURVEY.

Results from the survey are given as follows;

3.1 Road traffic congestion

3.1.1 Vehicle stoppages

On average, motor vehicle stoppages leading to traffic congestion were as show in figure 1.

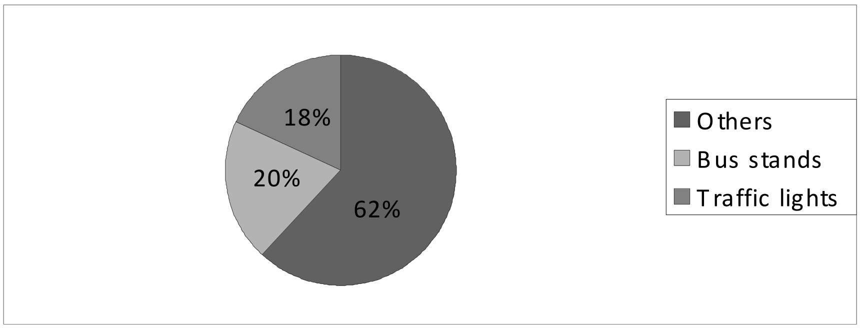
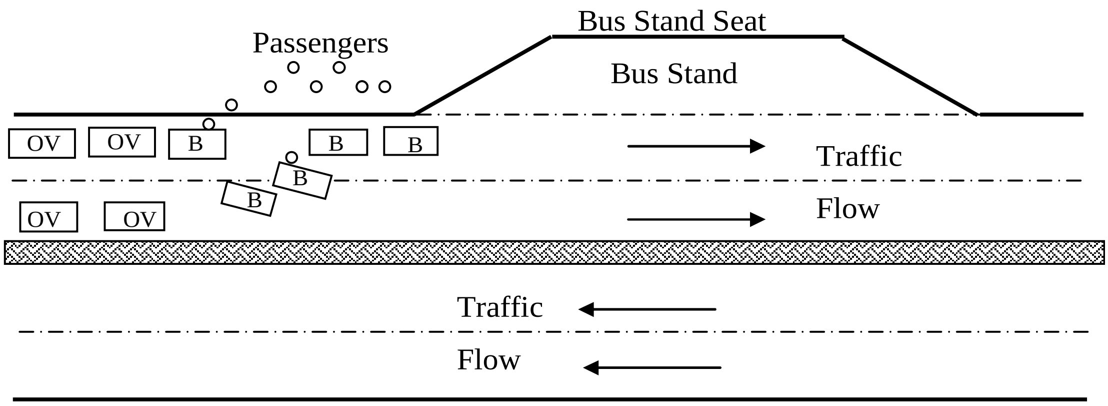


Fig. 1: Type and magnitude of motor vehicle stoppages in Dar es Salaam City [Author]

While stoppages at bus stands and traffic lights can be explained, the survey revealed that other causes were mainly a result of human factors and in particular, conduct and behaviour of vehicle drivers, other road users and the general public. The most common abuses of road use leading to traffic congestion were found to be as follows:

- **Unnecessary vehicle stoppages** on the road carriage way arising from vehicle breakdown and/or mere exchange of greetings among drivers.
- **Indiscriminate stoppage** of commuter buses (Popularly known as Dadadala) on the road carriage way to drop and/or pick passengers.
- **Improper location of bus stands**. There are many make-shift bus-stands and most of them are located near road junctions while others are located directly one another. In such circumstances, traffic flow is restricted to the extent of causing traffic congestion and/or accidents.
- **Competition and/or arguments among vehicle drivers**. In the absence of traffic lights, road junctions get jammed with vehicles for several hours because every driver has no time to let a colleague to pass. Such jams eventually lead to unnecessary traffic congestion.
- **Improper use of bus-stands.** Instead of using bus stand bays to drop and pick passengers, most (if not all) commuter bus drivers pack their vehicles on the road carriage way leaving the bus stand passenger bays empty as shown in Fig. 2. Worsestill, the bus that comes first will attempt to block the next one from leaving the stand allegedly for fear of losing passengers on the next stand. This behaviour results in restricting traffic flow which eventually creates the unnecessary congestion on the road as evident in Fig 2.



Key: B = Passenger Commuter Bus (Daladala); OV = Other vehicle

Fig. 2: Restriction of traffic flow by commuter buses at a bus stand in Dar es Salaam city (Bundara, 2010)

3.1.2 Improper use of Roads.

As a result of the slow moving queue, some drivers and particularly those driving commuter buses and the motorises popularly known as Bajaj's, abandon the road carriage way and divert to drive on the road shoulders most of which are not paved. This improper use of the road pollutes the soil on the road shoulders leading to worsening of the traffic congestion as explained later in section 3.3 of this presentation.

3.2 Floods

Dar es Salaam city is situated on the coastal belt of the Indian Ocean. It covers an areas of about 1,320,000 square kilometers of mainly flat built land, scattered ponds/valleys and bushy suburbs. The city has three seasons namely; dry season from June through October, short rains from November to December and finally the long rainy season from March to May. (JICA et al, 1995). With regard to the city's current physical topography and drainage system, the survey revealed the following scenerious.

3.2.1 Natural Valleys

Natural valleys for delivering rain water from upper lands into the ocean have been either blocked (turned into residential/business plots) or diverted from their natural routes regardless of the effect on such diversion on the flow of the said rain water. The Msimbazi and the Kimara/Sinza/Msasani (Bonde la Mpunga) valleys are cases in point (Fig. 3)

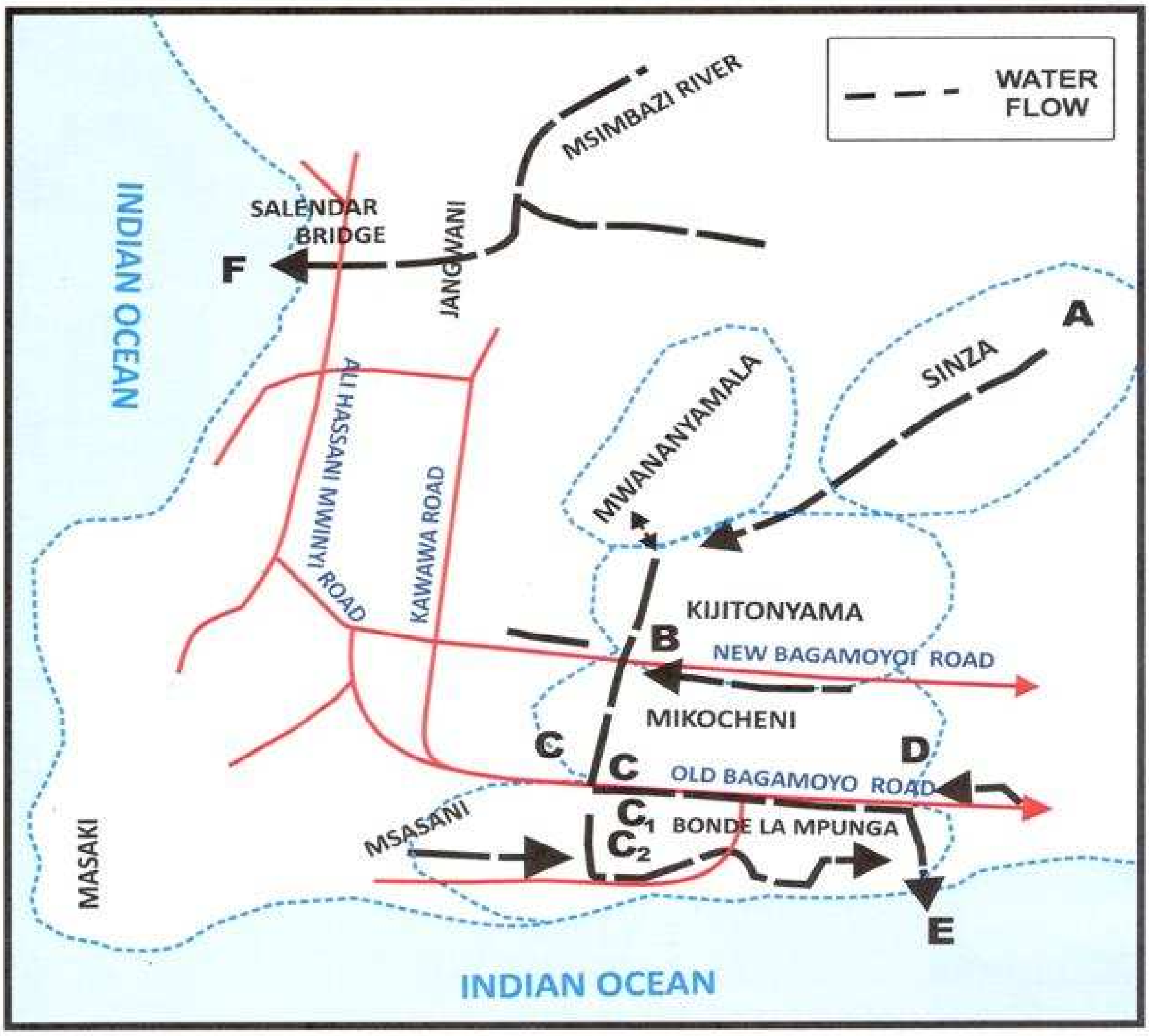


Fig. 3 The Msimbazi and Kimara / Sinza / Msasani (Bonde la Mpunga) Valleys Discharging rain water into the Indian Ocean

When planning the Sinza residential area in the late 1970s, the Kimara/Sinza/Msasani valley was left open. However, sometime in the early 1990s, the valley was turned into residential plots. As if this was not enough, on entering Kijitonyama and Mikocheni areas, the valley is narrowed by squatters and/or illegal plot expansions. Worsestill, after crossing the old Bagamoyo road (point c), the valley is diverted into two branches. One branch is a culvert running west along the old Bagamoyo road (C_1) which is almost blocked by soil/sand and various types of debris. The other branch (C_2) is an open channel the flow of which is subjected to a meandering route resulting from the sprouting buildings in the Bonde la Mpunga area, before discharging into the ocean at point E.

3.2.2 Drainage open channels

All drainage channels are full of soil/sand and all sorts of debris apparently due to the fact that the same are used as damping sites for both liquid and solid wastes. Such wastes include sewerage wastes.

3.2.3 Piped drainage system

Apart from being clogged with soil and/or debris, the piped drainage systems, though patched with larger pipes in some areas, is too old to match the current (2011) liquid discharge requirements. It is suspected that in the city centre, some of these pipes are totally blocked.

3.2.4 Rain water discharge points into the ocean

The entire city coast line is allocated to investors/individuals who not only raise their pieces of land to mitigate floods, but also block the natural water discharge openings into the ocean. The survey revealed that, despite the volume of water collected by the Msimbazi river and the Kimara/Sinza/Msasani valley towards the Msasani Peninsular (Fig. 3), there are only two rain water discharge points into the ocean. These are located at the Selander Bridge (point F) and Msasani area close to Mwalimu Nyerere's residence (Point E).

From the above presentation, it is clear that the smooth flow of rain water from the high lands through Dar es Salaam city into the ocean is prevented by mainly; blocking and/or diverting the natural valleys, clogging the drainage systems and blocking the natural discharge points into the ocean in the disguise of investments. When rain water is prevented from flowing into the ocean, it has no alternative but to bounce back and flow into low lands including roads. It is for this reason that there are persistent floods in Jangwani and adjoining areas, parts of Sinza, Mwananyamala, Mikocheni and above all Bonde la Mpunga in Msasani which is in naturally the lowest point of the Kimara/Sinza/Msasani valley.

In the author's opinion, all the above causes of floods depend on people's attitude, conduct and behaviour in upholding; personal responsibility, professional ethics, rule of law and above all, care for other people. As a matter of fact, in the absence of these key human factors, even the best designs for mitigating floods in Dar es Salaam city will not bear the expected results. Unless corrective action is taken sooner than later, the safety factor of Dar es Salaam city against abnormal floods is negligible.

3.3 Linkage between Road traffic congestion and floods in the city.

As results of traffic congestion, many vehicle drivers especially for commuter buses and the motorized tricycles popularly known as BAJAJ's, abandon the road carriage way to drive on the road shoulders in order avoid the slow moving queues. Since most of the road shoulders are not paved, this conduct results in polluting the soil of the shoulders through continuous compaction. This compaction pollutes the soil in that it changes its structure into a hardened soil mass on which growth of vegetation in inhibited. When this happens, the road shoulders are turned into pathways through which rain water will flow and wash away the soil thereby causing erosion of the shoulders. The resulting erosion of the shoulders will cause two problems. **One,** the loose soil will be swept into the road drainage system thereby preventing the smooth flow of rain water to cause floods on the road and adjoining areas. And **two**, erosion of the road shoulders will lead to water seepage into the road carriage way structure to affect its strength leading to failure of the same in the form of large cracks and/or holes. Both floods and holes on the road contribute to the creation of road traffic congestion as shown in Fig. 4.

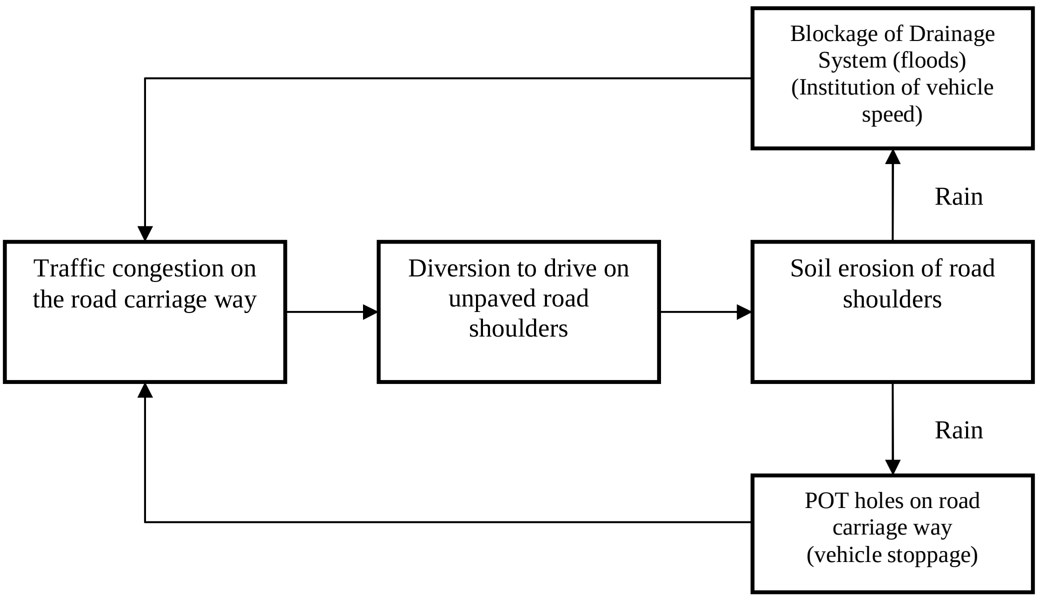


Fig. 4: Linkage between Road traffic congestion and Floods in Dar es Salaam City (Author)

4.0 CONCLUSION

A survey of the impact of human factors on mitigating road traffic congestion and floods in Dar es Salaam city has been presented and discussed. In conclusion the survey has established the following findings.

- Most of the vehicle stoppages (62%) leading to road traffic congestion in the city are mainly a result of the conduct and behaviour of drivers, other road users and the general public. These include; unnecessary vehicle stoppages, indiscrimate stoppage of commuter buses on the road carriage way, improper location and/or makeshift commuter bus stands, competition and/or arguments among drivers and improper use of bus stands.
- Floods in Dar es Salaam city result from causes which depend on people's attitude, conduct and behaviour in upholding; personal responsibility, professional ethics, rule of law and above all, care for other people. The said causes include; blocking and/or improperly diverting natural valleys for conveying rain water into the ocean, treating drainage systems as damp sites for both liquid and solid wastes and allocating the entire coast line to individuals without provisions for adequate openings to allow rain water to flow freely into the ocean.
- Traffic congestion results into reckless and impatient drivers abandoning the road carriage way to drive on unpaved road shoulders thereby causing soil erosion on the same during the rainy season. The resulting soil erosion blocks the drainage system in addition to damaging the road carriage way. A blocked drainage system causes floods which impede the movement of vehicles in the same manner as a damage road does. In other words, road traffic congestion and floods in Dar es Salaam city are interlinked.
- In mitigating both road traffic congestion and floods in Dar es Salaam city, people's attitude, conduct and behaviour are key factors which require serious attention, sooner than later.

5.0 RECOMMENDATIONS

In order to effectively mitigate road traffic congestion and floods in Dar es Salaam city, it is recommended as follows;

- Efforts must be made to change people's mindset through public talks/lectures, demonstrations and adherence to the rule of law. Everyone should evaluate own deeds instead of pointing fingers to others in the disguise of having no government power to do anything. Professionals and their associations must play a leading role in this matter.
- Use of the current road network be optimized through creation of ring roads, proper use of roads and especially bus stands and strict adherence to traffic rules. It is proposed that;

   - Commuter buses be forced to use passenger bays on a First-In-First-Out (FIFO) basis in which passengers will board the buses in the same manner. This can easily and cheaply be implemented by SUMATRA, Traffic Police and the general public.
   - Those driving on road shoulders should be heavily penalized and in any repeated incidence, their licences should be revoked.

- Natural valleys and drains for discharging rain water into the ocean should be re-established and adequate openings for discharging rain water into the ocean provided. Local government leaders in various localities should establish environment groups to monitor and maintain the drainage system at all times.
- All future designs/projects for mitigating road traffic congestion and floods be in Dar es Salaam or any other city/town in Tanzania must take into consideration human factors by involving the general public in every stage from conceptualization, feasibility studies, design, implementation, commission to operation. This can easily be achieved through the well established local government machinery in the country.

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DEALING WITH CONGESTION: THE REFORM OF PUBLIC TRANSPORT

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ABSTRACT

Urban centres are characterised by complex economic and non- economic activities. Dar es Salaam like other African cities faces a unique challenge of simultaneous high population and motorization growth. The swelling urban populations have resulted in an increase in public and private transport demand leading to traffic congestion, poor traffic mobility and safety hazards, causing inconveniences to passengers, commuters and residents in major cities particularly in Dar es Salaam. Other cities like Arusha, Mbeya and Mwanza are starting to face similar challenges. A sound transportation system is required to facilitate urban activities and determine the nature and pace of socio-economic development in these urban centres to meet the demand of people travelling to and between residences, business centres, offices, markets, recreation areas, public places, industries and others.

Dar es Salaam City with a population of over four million residents, the principal economic driver of the national economy has resolved to adopt an Innovative Transport System to improve public transit service, the "Bus Rapid Transit- BRT" sometimes referred to surface metro system that utilizes exclusive right-of-way bus lanes in the city. Important elements of the system are the introduction of high capacity buses, modal integration and equitable use of urban space for pedestrians, cyclists, public transport and mixed traffic which are paramount in facilitating smooth urban mobility. The new system has proved to be swift, efficient, and cost-effective in moving people in various cities throughout the world where it has been implemented. Examples of innovative and successfully implemented bus way systems are found in Bogota in Colombia and Curitiba in Brazil.

The introduction of high capacity buses will facilitate a smooth transition to a more efficient 'trunk and feeder bus routing system, increase private sector investment into the transit system, change private bus operating contracts to include quality of service requirements, facilitate integrated ticketing systems that allow for smoother transfer between different transit modes and increase the municipal capacity to plan, manage, and regulate its transit system. The need for a better mass transit system is supported by the National Transport Policy which puts emphasis on efficiency, effectiveness, competition, affordable services and environmental preservation and the City Transport Master Plan (2008). The Dar Rapid Transit Agency envisions facilitating better mobility for citizens that will contribute to the economic vitality.

Reforms taking place leads to a conclusion that to address urban transport challenges in a sustainable way. Policies which emphasise road sharing which entail making the road space beneficial to all users need to be instituted to mitigate negative consequences. Decisive policy decisions are also needed to constrain the growth of private vehicle trips for daily commuting to restore an equitable balance to urban transport network.

The paper highlights the state of urban transport challenges in Tanzania, the inception of BRT concept in Dar es Salaam, its development and the expected values of the project.

1.0 INTRODUCTION

Transport is an entitlement to all citizens and good transport networks have multiplicity of benefits; socially, economically, environmentally and culturally. Equity is also important as transport should be affordable to all so that there is equal and affordable access to opportunities of employment, education and social inclusion. Furthermore the paybacks in both direct and indirect terms are substantial and will contribute directly to improved economic performance, productivity and greatly reduce the negative stresses that citizens endure on a daily basis.

The increasingly difficult urban transport situation in the city, characterized by a high degree of traffic congestion, constrained resources for urban transport and deteriorating air quality, lies in the forefront of concerns. Urban transport problems are borne out of a set of complex and diverse environmental and economic factors and profound institutional failures. In Dar es Salaam, due to a low level of car ownership and high dependence on public transport, the problems of public transport are synonymous with the problems of urban transport because public transport vehicles (Daladala) serve such a large proportion of total trip demand. The Dar es salaam Master Plan (2008) provides that **majority of urban residents either walk and bike (56%), 41% use *public transport*, whereas only 3% use two and three wheelers and cars to move about. A similar situation is experienced in other cities.**

In view of the a foregoing the Government has vowed to address transport challenges with the introduction of the Bus Rapid Transit (BRT) with the essential associated administrative and institutional reforms.

2.0 PUBLIC TRANSPORT IN DAR ES SALAAM CITY

Dar es Salaam is the largest city in Tanzania and the country's centre of commerce and industry. The city is also an important terminal for air, sea, and road transport. Administratively it is divided into four local governments; the City Council encompassing the entire city area and three municipalities, Kinondoni, Ilala and Temeke.

The City has an area of 1850 square kilometres and is one of the fastest growing cities in Sub Saharan Africa with population currently estimated at 4.5 million inhabitants growing at 4.3% annually.

2.1 Development of public transport in Dar es Salaam City

Public transport in Dar es Salaam City started in 1949 when a private British company known as Dar es Salaam Motor Transport Company (DMT) started offering public transport services. Following the Arusha Declaration, DMT was nationalized in 1967 and was transformed into a national monopolistic Parastatal organization - *Shirika la Usafiri Dar es Salaam* (*UDA).* However, UDA failed to meet of the public transport demand in the city, leading to long queues at the bus stops causing inconvenience to the passengers. The company's services deteriorated due to poor management and lack of Government subsidy to sustain the low and un-economic fares fixed by the Government.

Urban public transport structures in Dar es Salaam like other developing cities have experienced demise through poor public sector management and a failure to satisfy market demand resulting in a decrease in publicly operated services. This has led to a corresponding increase in less-organized private operators who have filled the supply 'vacuum', as is the case with the daladala operators in Dar es Salaam, Matatu in Kenya and Twegerane in Rwanda. Service offered by present public transport system leaves much to be desired.

2.2 Daladala operations and their inherent problems

Currently public transport service in Dar es Salaam is provided by an estimated 7,000 minibuses commonly known as daladalas with capacities ranging from 15 - 25 passengers. These are mainly owned by individuals entrusted to drivers who have to deliver a daily revenue target depending on the size of the minibus.
The fact that daladala buses are mainly second hand vehicles which are plagued by a number of operational problems including lack of professional management, bad driver behaviour, overcrowding, route shortening and frequent break downs their large number adds to raising problem of traffic congestion caused by rising car ownership, pollution and long times spent commuting in daladala buses.

3.0 THE DAR RAPID TRANSIT SYSTEM - DART

Dar Rapid Transit – DART is the ***Bus Rapid Transit – BRT system*** being developed in Dar es Salaam City. It is a bus based mass transit system intended to increase public transport capacity and mobility.

3.1 DART Vision and Mission

The **DART vision** is *"to have a modern public transport system at reasonable cost to the users and yet profitable to the operators using quality high capacity buses which meet international service standards, environmentally friendly, operating on exclusive lanes, at less travelling time"* and the;

DART mission is *"to provide quality, accessible and affordable mass transport system for the residents of Dar es Salaam which will subsequently enable poverty reduction, improve standard of living, lead to sustainable economic growth and act as a pioneer of private and public investment partnership in the transport sector in the City"***.**

The DART system has been designed taking into account all specialized infrastructure for a bus rapid transit system similar to one developed in Bogota and other cities throughout the World. The thrust of DART development is a clear division of roles. Infrastructure planning, developing and controlling be provided by public institutions whereas operations and fare collection are provided by private companies through concession contracts. Below is a brief account of the key components.

3.2 Specialized infrastructure for the system

The general concept of DART is centred in "Trunk and Feeder" service therefore its infrastructure includes dedicated busways with overtaking lane at stations, feeder bus stations, crossing facilities, depots for bus parking and maintenance, and an advanced control system. The design for Phase 1 has also provided for **29 stations**, **6 integration/feeder stations**, **5 terminals** and **2 bus depo**ts. Below is an architectural impression of a bus station design showing some of the facilities, overtaking lane and crossing facilities (raised flat top hump).

Fig. 1: Proposed view on a typical DART station

Busways will be the central lanes of urban highways; one lane for each direction built in concrete and will be reserved for buses in the proposed DART corridors. However, stations will have two lanes of busway per direction to allow for overtaking.

The stations will be located strategically to cater for potentially high passenger movements and takes into account existing bus stands along the corridors. They will be located in the median approximately 500-600m apart with pedestrian access provided with safe crossing facilities. Terminal stations have been located at endpoints of the DART corridors and at locations where passenger demand dictates and sufficient convenient and accessible land is available.

Walkways, plazas, and bike ways will also be constructed to supply pedestrian and bicycle access. Parking and maintenance areas for the buses will also be built with public funds and assigned to the private concessionaries of the system. For real time supervision DART infrastructure includes an advanced control centre.

Once implemented, the system is expected to include about 130 km network of bus ways, with over 200 route-km of feeder roads. Infrastructure will comprise segregated and priority bus lanes, stations conveniently located, with level access to the buses, terminals, pedestrian facilities and parking.

The DART system is proposed to be developed in ***six phases along the six main corridors/arterial roads*** in the city. The six key corridors identified for the short and medium term development include Morogoro road (west), Kilwa road (south), Ali Hassan Mwinyi-Bagamoyo road (north), Nyerere road (south-west) and Mandela -Sam Nujoma (outer ring road), Kawawa road (inner ring road). The Phase 1 corridor is being implemented whereas Phase 2 and 3 is being designed. Development of the DART is expected to have a major impact on Dar es Salaam development.

3.3 DART System Operations

3.3.1 Buses

Capacity: The proposed system designed for Dar es Salaam is based on a trunk-feeder system using the same concept used in South America, the most successful BRT in the world so far. The concept is based on the use of high capacity buses on segregated lanes, and feeder buses – that can be normal buses or microbuses – integrated to the system on special terminals and transfer points. Based on this concept, financial modelling, projected demand and pavement design, a 140 passenger articulated bus with 90 cm high platform has been adopted for the trunk routes and a 50 passenger 8.4m bus for the feeder routes. The trunk route buses will provide both local and express services.

Fleets: The operating design is based on morning peak hour demand, as it represents the most critical public transportation scenario for the day**.** Three main factors that determine the bus fleets are:

- (i) Assigned dispatch frequency;
- (ii) Complete cycle travel time;
- (iii) Vehicle's nominal passenger load capacity at peak hour, taken as 100% of vehicle's maximum capacity of 140 passengers and feeder vehicles with capacity of 50 passengers. The design anticipates 18 operating hours from 0500 to 2300.

Based on the above stated factors, it has been established that DART system will operate seven trunk lines service, using (145 nos) -18 meter long articulated buses with a 140 passenger capacity, and 9 feeder line services, using (118 nos) - 8.5 meter long buses with a 50 passenger capacity. The design has projected a total of 380,000 passengers per day and 114 m trips annually.

Based on careful analysis, terminal stations have been placed mainly at endpoints and also where special treatment is required regarding passenger demand, high flow of pedestrians and integration with alternate transportation means. Terminals are located at convenient area in size and accessibility, to avoid congestion and additional distance traveled for feeder and trunk system users. For DART's first phase the following terminal stations have been defined:

- Kivukoni Terminal – located at Kivukoni area next to Magogoni ferry port.
- Kariakoo Terminal – located along Msimbazi Street on the plot next to the railway and Nyerere road intersection.
- Ubungo Terminal – placed in front of Ubungo upcountry terminal (Stendi ya Mkoa) at the middle of Morogoro road axis.
- Kimara Terminal – located at the end of Morogoro road corridor around the existing Kimara bus
- Morocco Terminal – based on preliminary information it will be located at the intersection between Kawawa road and Bagamoyo road.

The Phase 1 system will have 15 feeder routes. Feeder services will be offered at Ubungo Terminal, Morocco Terminal and at Shekilango, Urafiki Mahakama, Magomeni Mapipa and Fire stations along Morogoro Road. Along Kawawa Road corridor feeder integration will take place at Usalama and Kanisani stations.

3.3.2 Operational Control

The BRT concept is based on high performance and high quality of services. To control operation, there is a need to control all system elements. Everything concerned must be in place before it starts, since operation influences services quality directly, and if it does not work properly, cost can significantly increase. The high quality of operational services guarantees the system's credibility since its beginning.

There is a permanent ongoing process to keep the system optimized, which consists of planning and scheduling, operation, monitoring. The system is modular and can easily be adjusted to changes in demand pattern, except for some issues, that might need effective actions as new investments.

Monitoring levels of quality is among the priority issues addressed by the Agency. User satisfaction surveys which will give the perception of the user about the system are being planned to enable the Agency develop an internal history of performance and levels of service which will help on developing alternatives to give better service.

DART Agency has also commissioned a design for the communication centre where the intelligent electronic system for monitoring the DART system operations and other traffic to avoid unnecessary conflicts and delays.

3.3.3 Sustainability of Service

The objective of planning and implementing the DART system is to transform Dar es Salaam's informal system of daladala minibuses into a customer-oriented public transportation service, once DART system becomes operational about 45 daladala routes that that currently operate on Morogoro and Kawawa north roads will be phased out.

The DART Agency has placed a priority on participation of existing commuter bus operators in the system. Subsequently DART Agency engaged a consultant to carry out the study and proposed better ways and techniques to be deployed by the Agency to properly involve and engage current daladala operators in the DART project. The aim of the study was to develop mechanisms that will be used by DART Agency during the first phase of the project to properly and effectively involve and engage the current daladala operators in the DART project so as to avoid negative impacts to drivers, owners and conductors. The consultant conducted an intensive participatory study to identify current operators including Drivers, Owners of the daladala and the conductors, further current operating routes and management structures of the operators that include employment structures and their organization structures were reviewed.

The Agency and the licensing authority/SUMATRA will identify alternative routes for the affected roadworthy daladalas.

3.3.4 Operating Agencies

The system has four actors. DART, a public agency, will regulate and manage the system and the service. Two private sector bus companies and one private sector fare Collector Company will provide the system services, which will be competitively procured. The firms will be awarded 20 year concession. Finally, one competitively selected fund manager will ensure fiscal accountability and transparency of the fare revenue. The agencies' tasks are as summarised below:

- ***DART Agency*** – a new government agency responsible for overall management of the system, policy-setting, regulation, planning and controlling of operations and marketing.

- **DART Fare Collector** – one private sector company responsible for daily fare collection, maintenance of the physical infrastructure at the bus stations, acquisition and maintenance of equipment, including communication equipment, used at the station, as well as cleanliness and security at stations.

- ***DART Bus Operator(s)*** – two private sector companies responsible for acquisition, operation and maintenance of buses along specified trunk, complementary and feeder routes.

- ***DART Fund Manager*** – one institution responsible for financial management and reporting, liquidity control and payments to the system actors (bus operators, fare collector, DART agency and the fund manager).

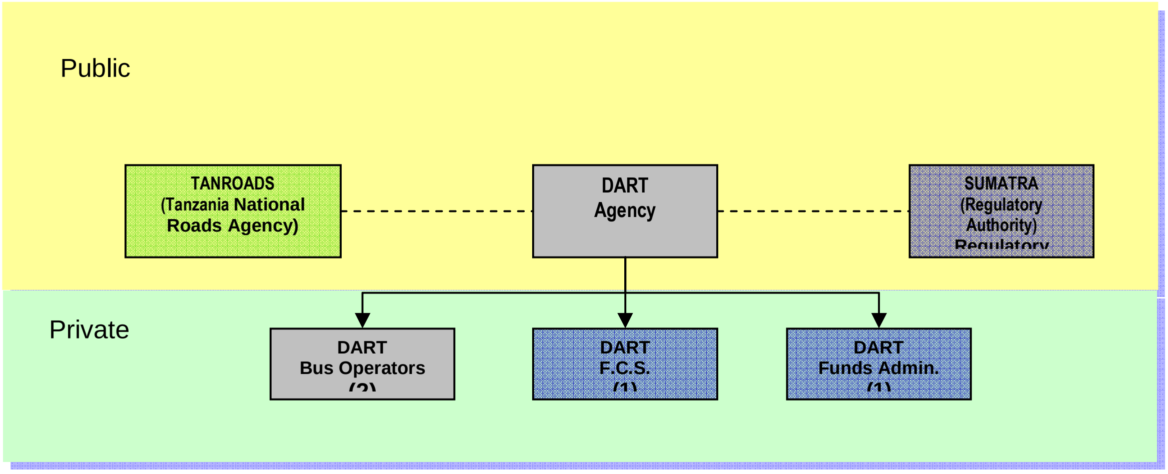

Fig. 2: DART Operating Agencies

DART Agency will also engage a Systems Auditor to carry out regular audits of the system including operations, revenue collection and disbursement.

4.0 WHAT DART HAS MEANT TO THE PUBLIC TRANSPORT IN TANZANIA

4.1 Institutional Development

The DART project has influenced development of effective institutions for managing transportation in the city. The Dar as Salaam Rapid Transit (DART) Agency will guide development of the Bus Rapid Transit (BRT) system in Dar es Salaam including planning and implementing for non-motorized transport users, improved traffic circulation at intersections and ensuring public transport systems are well coordinated to facilitate orderly traffic flow.

The key issues are looked at together considering their connection and integrating their complementarities in terms of expertise as well as intervention. The need for linking urban transport with other sectors like land use planning, poverty alleviation, environment, and energy is also given adequate attention.

4.2 Development of Integrated Transport Master Plan

The BRT is an excellent initiative and its introduction has received tremendous support in Tanzania. However some review was considered necessary in the following areas:

- Integration with associated passenger services
- Traffic movements (intersection management)
- Impacts on other transport functions (taking a holistic view)
- Greater chance of success (not a compromise of BRT)

In view of this, a programme has been initiated to develop the city ***Transport Policy and Systems Master Plan*** with Japan technical and financial assistance through JICA.

The JICA study for Dar es Salaam Transportation Master Plan was mandated to develop an Integrated Transport Plan covering the development of transport networks synchronized with urban development in the City.

- The overall goal of the Study is to formulate Urban Transportation Policy and System Development Master Plan with the target year of 2030,
- The short-term objectives: formulation of an urgent action plan to alleviate the current traffic congestion and prepare Preliminary Feasibility Study (pre-FS) for the selected priority projects.
- In order to assure effective implementation of the proposed projects, a Capacity Development plan should also be developed, focusing on the improvement of technical and management capacity of the relevant agencies.

4.3 Behavioural change of citizens (including youth) and relationships between urban transport stakeholders

The image of working in public transport is low and it is difficult to attract good employees. In addition, the value and experience of those already working for public transport entities are often ignored. As part of preparations for the DART Project public education and awareness is conducted through radios, TV and other media. This has brought about public awareness on the use of transport facilities and appreciation to the sector.

The awareness also includes customer care issues as well as how to deal with disadvantaged groups like students who are considered as a burden as they deny operators revenue. On the other hand students who enjoy low fares dictated by the government are encouraged to use public transport.

4.4 The Public Private Partnership (PPP)

The DART project gears to set a sustainable Public – Private partnership in the improvement of Dar es Salaam City public transport system. While funding for the infrastructure is coordinated by the Government, investments in vehicles to operate the system will be largely a private undertaking and its financing will be essentially private.

Where the DART Phase I is being developed private bus owners have been involved in the process of developing the new system and appear to have appreciated the opportunities for far better returns in the system. They however lack the ability to raise financing on individual basis lacking equity of their own as well as track record and collateral needed to raise loan financing.

The Government approach taken has been to encourage the private bus operators to join hands with reputed operators in order to improve their chances of participating in the BRT bus operations.

4.5 The Private Sector Provision

Private finance is a predictable source in developing a sustainable system. In Tanzania there is the National Social and Security Fund (NSSF) for example which has extensive experience in development projects with fair return. The DART Agency is open to private finance initiatives. What the Agency does is developing conducive investment climate, what investors want is the assurance that the invested money can be recouped. The Agency is aware that private finance deal is usually complex involving a number of people of different skills and knowledge. One of the key factors is risk; capacity development is inevitable to enable the Agency assessed properly.

5.0 PROJECT IMPLEMENTATION

5.1 Infrastructure development

The President of United Republic of Tanzania launched DART Infrastructure construction for the Phase I on 10th August 2010. The President **His Excellence Dr. J.M. Kikwete** said that it is high time DART Agency considers the use of CNG in buses right away since there is abundance of the gas in the country. In view of that the Agency commissioned a study to analyse the effective energy for the Phase I buses. The study reveals that Euro 3 or 4 Diesel is cost effective and equally environmental friendly.

The activities implemented includes the construction of 21 kilometres of roads with exclusive BRT bus lanes, mixed traffic lanes, bicycle lanes and pedestrian lanes; construction of five bus terminals, two bus depots and six feeder transfer stations. Dar es Salaam BRT system is as shown in the figure below.

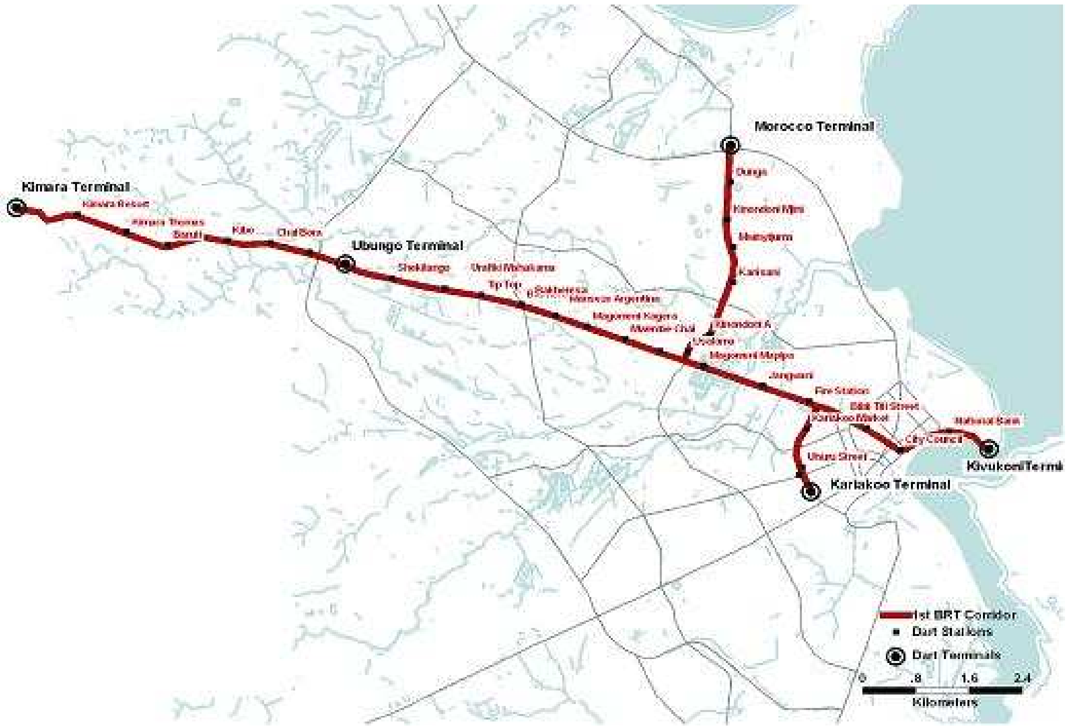

Fig. 3: DSM BRT Phase I system

The infrastructure development contacts are in seven packages to ease and speed up construction pace.

Package	**Name of Contractor**	**Contact duration (Months)**
Package No. 1 : Road works development in 2 Lots	Procurement process is being finalised	24
Package No. 2: Ubungo Depot and Upcountry Bus Terminal	Beijing Construction Engineering Group Co. Ltd (BCEG).	24
Package No. 3: Jangwani Depot.	China Civil Engineering Construction Cooperation	24
Package No 4: Kivukoni Terminal.	BCEG	12
Package No. 5: Kariakoo Terminal	BCEG	12
Package No. 6: Feeder Stations	BCEG	24
Package No. 7: Power Utility Relocation.	Spencon Services Ltd	6

Detailed Design of Phase II and III

In another development DART Agency has engaged the consultant, that is, M/S Kyong Dong Engineering in association with Ambicon (T) Limited to carry out detailed design for phase II and III of BRT system. The main emphasis of the task is to have a functional BRT system network with both Trunk and feeder buses operate along the Kilwa Road corridor (CBD to Mbagala and part of Kawawa road connecting Kilwa road and Magomeni) and Nyerere Road corridor (from CBD to Gongo la Mboto area).

6.0 CONCLUDING REMARKS

Planning the DART has demonstrated that the degree to which self-sustaining change occurs is directly related to the degree to which people participate in the planning, implementation and evaluation of the projects. Through stakeholders' involvement and Political commitment the following have been achieved:

- enthusiasm to address the city transportation challenges
- commitment to mobilize financial resources, the government and stakeholders in the private sector are willing to provide,
- willingness of development partners to support and
- establishment of an effective institutional arrangement.

Urban transport challenges require Urgent measures. There are many ways to address the challenges; cities are encouraged to adopt reforms however, it is important to note that good governance and stakeholders' involvement are critical factors in managing the desired change

The implementation of the BRT system will significantly improve Urban Transport and Mobility in Dar es Salaam city and is expected to be the role model for establishing similar BRT systems in other emerging cities of Mwanza, Arusha and other cities accordingly and thereby mordenise Urban Transport and Mobility in Tanzania**.**

The establishment of DUTA has to be fast tracked as it will be a major institutional reform that will help to implement strategic policies being developed for Urban transport and mobility. In so doing urban transport and mobility in Dar es Salaam will improve significantly.

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LAND-USE CONTROL A NECESSARY ADDITIONAL TOOL FOR THE SUSTAINABLE URBAN TRANSPORT IN TANZANIA

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ABSTRACT

This Paper presents analysis of the way forward in achieving Sustainable Urban Transport in Tanzania, it discusses how informal developments orientation, household travel behaviour caused by uncontrolled land-use influences accessibility to the Public transport system and how affordable mobility depends on the community orientation to the public transport system, gives evidences on effects and challenges to achieve integrated sustainable transport system that counteract with the sprawl developments and traffic congestion to increase accessibility to all and affordable transport system with positive economic externalities to urban dwellers.

Results from household survey in Dar es Salaam city reveals the facts on challenges that might affect sustainable urban transport system that is affordable, equity and enhance poverty reduction. The paper has a wide range of practical applications, from informing policy-makers importance of Land-use and transport planning integration for the reduction of transport problems and challenges to the implementations of the high occupancy transport schemes in urban areas, also attracting transport planner's objective tools that will deal with transport demand rather than supply.

It's hoped that with additional case studies to this paper, Planners will be possible to isolate the most important influences on travel patterns and confirm whether more thoughtful land-use and transport planning that will encourage public transport usage and maximise transport benefits to urban dwellers counting reduction of congestion, environmental impacts and socio-economic development.

1.0 INTRODUCTION

Public Transport in sub-Sahara Africa cities is facing a number of challenges, not the least of which is increased congestion delay associated with large greenhouse gases emission, reduced public transport patronage and transport related fragmented Policies and tools. **GoT** concluded under **DCC** and **DART** to implement Bus Rapid Transit (BRT) and Formulation of the Dar Master Plan as the strongest intervention measure for the transport problems of Dar es Salaam city, (**DCC, 2006, Hertel, C., 2008 and JICA, 2008**)**.** If implemented correctly the BRT projects in DSM will need to be integrated with the existing essential transport modes for the efficient and effective accessibility that is sustainable and affordable to ensure that major transport modes will not be competitors of BRT but complementary ones to make a seamless set of options serving all aspects of travel demand. The positive result of the projects should bring down and hold congestion and pollution levels experienced as well as increased available transport options for those who are disadvantaged in terms of their mobility.

The rapid population growth in the major cities of Sub-Sahara Africa, Dar es Salaam in particular has resulted in unplanned Urban sprawl with poor transport facilities, which resulted to poor accessibility, especially to informal settlements (Squatter developments) in outskirts of Urban districts. The effect is also contributed by land development being ahead and conflicting with land-use planning. Non car owners living in informal and sprawl developments are despite of all other transport problems, they are in additional faced with specific problem to access into the public transport stations due to lack of well-regulated public transport, lack of road connectivity and comparable large distance from bus stops to home. All these typical problems and the congestion problem has contributed into the innovation of public transport using motorcycle in the Dar es Salaam city commonly known as ‘Boda-boda’ which can intellectually mean short-cut public transport modality, majority of sprawl dwellers who don’t own car are therefore depends on Boda-boda to access public bus transport operated on main-arterial roads, Boda-boda users gets another additional credit that, the mode has ability to manoeuvre through congestion and drive ahead traffic jam to reduce travel time during peak hour and can access informal Land-use developments in areas locked without proper roads.

Despite of Boda-boda being increasing mobility to the non-car owners in sprawl communities and give employment opportunities to the non-well educated youths the mode is faced with challenges mainly being caused by lack of proper regulations, associated with large accident fatality rate and high fares that is the major contribution of the increases transport expenditure burden to the users and it hinder high occupancy transport modes and reduce Public transport patronage.

Dar es Salaam Urban Transport System overview

Dar es Salaam is the capital city of Tanzania, with approximately 3.4 million inhabitants occupying 1,393km^2, this makes Dar es Salaam the top denser cities in Tanzania with 2441-Inhabitants per km^2, it’s amongst the faster growing cities in Sub-Sahara Africa with growth rate of 4.3% (**NBS, 2007**). Private Car ownership is estimated to 30 cars/1000-Inhabitants, the average peak hour vehicle travel speed is 11km/hour during peak period, (**JICA, 2008**).

45% of Dar es Salaam citizens are working in non-official business sectors, poverty is increasing at a rate of 18%, basic needs poverty line is TZS.13,998.00 per person per 28-days, 34% of the population fall below the basic needs poverty line (**NBS, 2007**). Dar es Salaam City transport system is depending on the private individual owned buses (Dala-dala) to operate public transport geared with motorcycles operations and taxi.

Main **transport problems in Dar es Salaam** are increase of congestion associated with large travel time delay, poor service given by Dala-dala, increased road accident rate

(8.4%), increased private car use and environmental degradation, 90% of Public transit buses are old above 10-years, increased pollution rate, no headway management, no priority given to Dala-dala in using roads and their operations. Other Problems are Poor road connectivity, inferior and fragmented transport institutional capacity, lack of effective Traffic Management, Pedestrian paths are used for parking and vendors and non-effective regulation of transport system. Nevertheless all current efforts in plan likewise the planned BRT system, it seems most of these transport problems will not be solved without the integration of land-use and transport planning tools making them working in synergy to revamp the metro transport systems in Tanzania.

A study by **Olvera et al. (2003)** advocated that major cause of the traffic congestion and allied transport problems in the Dar es Salaam are generated from the poor land-use development where all necessary human needs including port activities and official business are located in the city centre and land locked sprawl development (unplanned land-use). Their paper also mentioned lack of services like schools and heath units within or close to residential as the major contributors of large demand from communities to the city centre, it's this sprawl development and congestion which seems to attract the use of Boda-boda as alternative transport mode to serve demand that high capacity modes has neglected due to relatively high unit running cost, and inaccessible urban areas to enhance feeding and distributing passengers to the major dala-dala bus stops.

Dar es Salaam Bus Rapid Transit - DART

Dar es Salaam - BRT system design report by **Logit in association with Inter-consult limited (2006 and 2009)** shows that the long term conceptual design and detailed design of initial corridor (Phase-1) depends on the following transport features; segregated median bus lane, Planned to use articulated 140 passengers capacity buses (EURO-3 standard) – expected to transport about 48,000 passengers per hour per direction equivalent to 380,000 passengers per day for phase 1, quickly boarding and alighting on a level platform, enclosed stations, pre-boarding fares collection to give a bus station high capacity of operating. Long term BRT network plan is 130.3km of road with 18 terminals and 288 stations to be implemented in geographical phases, the new road infrastructure shall have two lane both directions for mixed traffic and one lane for the both directions for the BRT operations, distance between stops is planned to be 500m. The design adopts concepts of High Occupancy Public Transit from Latin America. Map in **figure 1-1** and **1-2** below shows BRT implementation network for full system (BRT long term conceptual design) and Implementation plan (Phase-1).

Failure of timely land acquisition is mentioned as one of the project delay causes, BRT was expected to start operations in year 2009 but is still under construction, this land problem facing BRT is one of the associated poor land-use development control that in this paper is given attention for the establishment of proper policies under the integrated Land-use and transport planning to maximise sustainability of Urban transport in Tanzania.

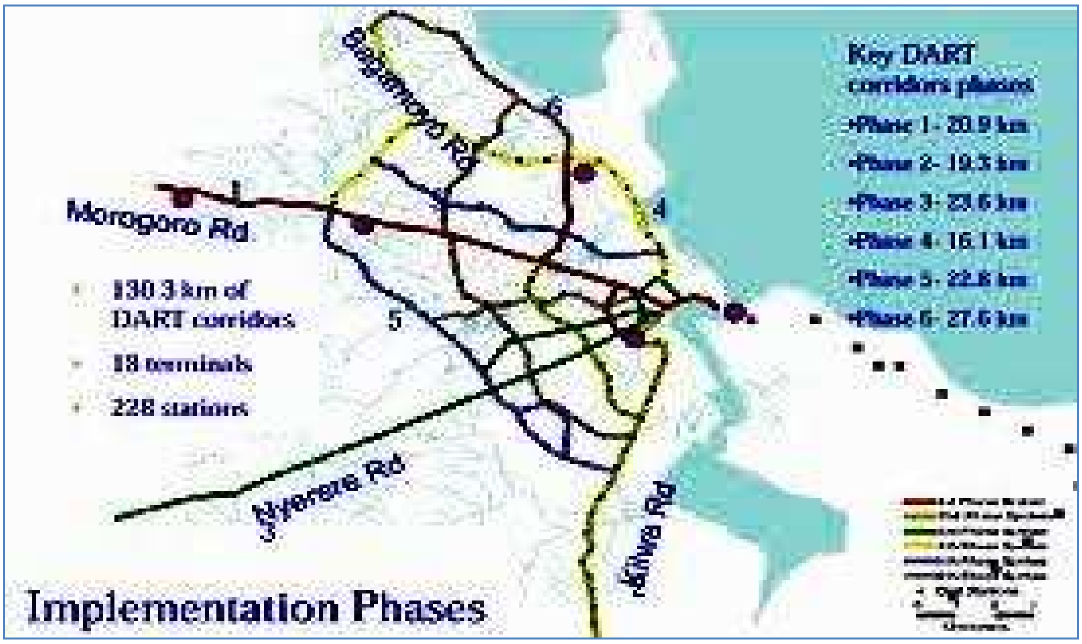

Fig. 0-1: Full System (Source: DCC, 2006)

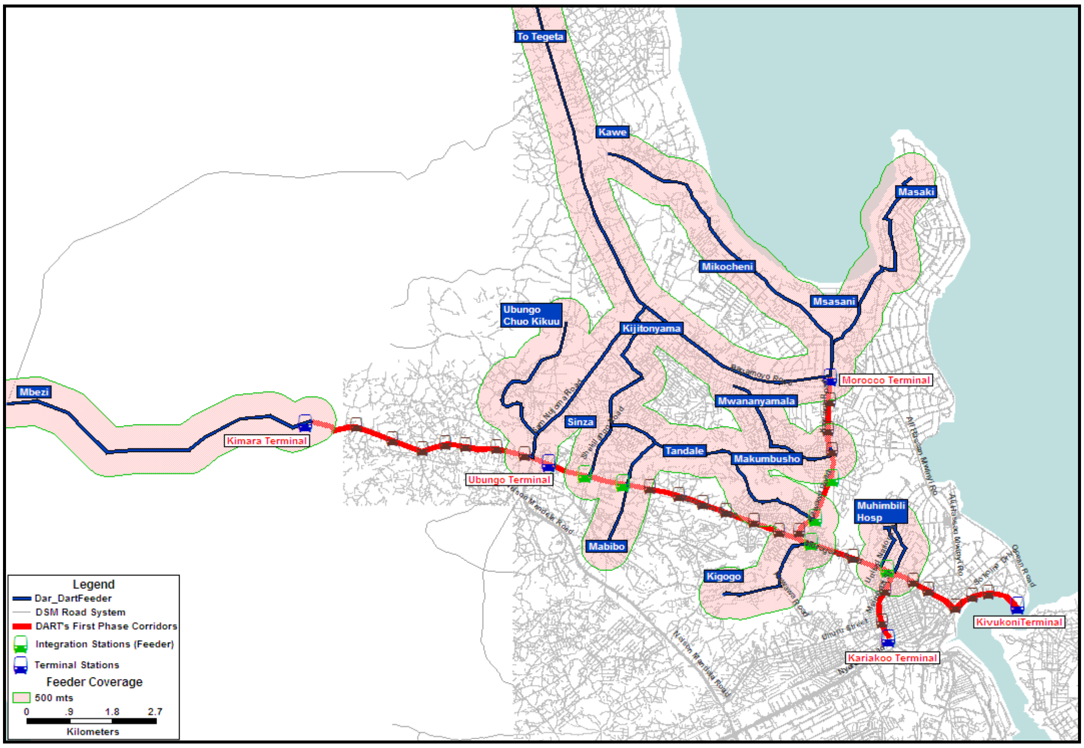

Fig. 0-2: BRT Phase 1 System (Source: DCC, 2006)

Technical Paper Title and Objectives

This IET technical paper for the 26th National Conference aiming at addressing traffic congestion challenges and enhancing road safety for National Development took specific title as "**Land-use Control a necessary additional tool for the Sustainable Urban Transport in Tanzania**". The key paper question is to raise importance of how Land-use and Transport policies can be integrated to reduce congestion effects and increase socio-economic benefits to Tanzania urban dwellers".

Paper also analyses and assesses household travel behaviour and characteristics to identify and outline strategic tools needed to package in synergy with Public transit Policy (e.g. BRT in Dar es Salaam) and current Transport plans for the achievement of sustainable development. The paper is therefore addressing the impact of informal development to the urban Transport system, especial patronage, to inform the future theories on the lesson for the integrated land-use and sustainable urban transport system in Tanzania.

2.0 LITERATURE REVIEW BEHIND THE PAPER

This paper considers Sustainable transport system as the development objectives that lay its policies to achieve economic development while preserving environmental and ecological system, improve quality of life, and ensure equity in the society, This study is also keeps aware that Sustainability is the key appraisal indicator for the internationally feasibility of any Development Project that meets the UN treaties introduced in the **Rio Declaration** and UN-Agenda 21 (**UNCED, 1992**) and its amendments made in Kenya in year 1982 and Johannesburg South Africa in year 2002 where UNCED sets sustainable development roots on the development for the people of today and tomorrow and limiting environmentally destructive actives and promote use of the appropriate technology and policies to solve environmental problems. This paper also takes the guides from **Hall, R.P. (2010)** and **Litman, T.A. (2011)** that defines sustainable transport as a transport development in three dimensions of social, economic and environmental protection goals, called triple bottom line (**see figure 2-1**) .

Land-use planning is defined in this technical paper as the development planning objectives focusing on land-use factors such as density and clustering, mix neighbourhood, location of activities to establish a community density or urban form, it's also agreed that Land-use and transport are mutually related for the better functioning of the system and achievement of sustainable system, being led by **Giuliano, G. (1986)** observations that characteristics of the transport system is what determines accessibility and also accessibility is affected by the location of activities. This means our planners can determine level of accessibility they need by using location of activities within the urban land, and hence the form and type of land development and its orientation can determine level of transport accessibility and reduce congestion while increasing Transport socio-economic benefits. **Hall, R.P. (2010)** also elaborated that, sustainable transport system is that transport system which sets its objective policies on the integrated transport and land-use development. The success system has to focus on the synergy tools that work together and assist each other, by ensuring that Land development is controlled and integrated with transport system to ensure that demand matches supply at all times. From this literature review it's advocated that successful transport system needs to set its success on the following objective framework context: -

a) Improvement of economic performance.

Transport system and travel pattern has to be integrated in such a way that it makes a maximum use of local available resources to improve social welfare by increasing productivity, employment opportunity, business activities, properties values and tax revenues

b) Reduction of environmental impacts

Integrated urban transport that reduces amount of adverse impacts of transport and land-use to the global and local environment; regional/Global environmental impacts of transport system are Greenhouse gases (CO_2, CH, CH_4), and Volatile Organic hydrocarbon (VOC) all these are emitted from car engines as a by-product of fuel combustion and unburned fuel. CO from engines undermines blood ability to carry oxygen. All emission gases are inhale-able and toxic to human health while greenhouse gases are also ozone originator and causes climatic changes

c) Deliver safer roads for all road users

Transport system that focuses on the level of accidents to reduce associated deaths, permanent disabilities and losses of properties and productivity in the society. Planned system has to set strategies on how to reduce the effects and causes of accidents.

d) Improve accessibility opportunities for all

System that reduces transport costs, barriers and risks that prevent peoples from reaching designed destinations, opportunities to interchange and integrate with other modes, increase mobility; promote access to all parts of the city network connectivity and reduction of congestion.

e) Reduction of inequalities across the system

Transport system that gives special attention for disables, old people, school children, and low income societies; operate at affordable pricing and give value for money system.

Visual representation of the triple bottom line in **figure 2-1** below shows interactions of policy tools for the sustainable transport system whereas the tools that fall in the comprehensive sustainable region are the best synergy tools for the sustainable transport system.

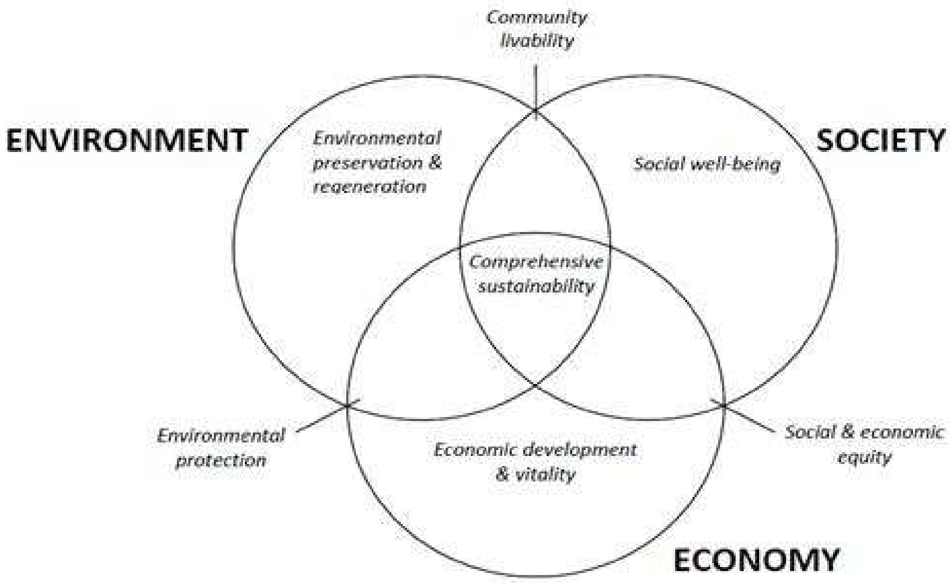

Fig. 0-1: Triple Bottom line (Source: Hall, R.P, 2010).

Yigitcanlar, T., et al., (2008) argued that the key Problems on achieving sustainable Urban transport system in developing countries are Pollution emissions, congestion and accidents fatality, attention is also made to **Guillen, M.D.V. and Haruo, I., (2004)** they mentioned big issue in urban transport planning for sustainability in developing countries is how to integrate policies serve low-cost households and intermediate to achieve higher social-economic benefits. This paper defines BRT as a mass transit bus system emulating rail transit at low cost that relies its principals on high quality customer oriented bus services (Branding and marketing for public bus transit operations), running on exclusive right of way with dedicated stations and pre-boarding fare collection, traffic signal priority, high quality bus stops and high frequency services, (**Wright, L. and W. Hook., 2007).**

3.0 EFFECT OF UNCONTROLLED LAND-USE DEVELOPMENT TO THE DAR ES SALAAM TRANSPORT SYSTEM

A study by **Ojoro, GOM (2011)** established that travel behaviour in Dar es Salaam and the increase of informal developments are both influenced by household orientation to the Public Transport catchment area, household income, Location of activities, number of school children in the household and whether the household head is employee or not, with Poor Land-use control being the focal point of the Problems.

Among the associated problems that will remain unless the use of integrated land-use and transport policies is made shall be increased informal developments (Squatters) leading to unmatched travel demand, increased congestion due to increased travel potential and Poor location of activities, inequity transport system with hindrance of sustainable modes like walking and cycling, Poor accessibility, poor feeding of the Public transit like BRT system and increased car use.

The study of Dar es Salaam transport system evidenced this; that travel Potential is higher in outer zones and squatter development compared to the inner zone and planned areas; travel time to work from outer zone is almost three times that in inner zone; it takes about **170** minutes travel to work in outer zone compared to about **57** minutes only in inner zone. Average distance to work in outer zone is twice of that in inner, same to distance to nearest bus stop is much higher in outer zone than inner zone. Catchment in outer is therefore solicit private car usage (**Ibid**). T**able-1** below illustrates differences in transport statistics due to land-use effect.

Table 1: Zonal Summary Descriptive Transport Statistics

Calculated Household travel characteristics variables	**Mean Statistics**		**Sample Data p - Value**	
	Inner Zone	**Outer Zone**	**Inner Zone**	**Outer Zone**
Peak hour Travel Time to job (**min**)	56.86	170.28	0.001	0.131
Distance from home to Job (**km**)	11.6	20.3	0.001	0.159
Distance to nearest Bus Stop (**km**)	0.4	2.3	0.001	0.001
House Hold size (**Person/Household**)	4.04	4.13	0.309	0.352
Household travel to work demand (**Person/day**)	2.42	2.97	0.001	0.001
Monthly travel expenses (**TZS**)	70,104.32	146,649.24	0.027	0.027
Monthly income (**TZS**)	324, 265.18	441,853.90	0.001	0.001
Household Children going School every day (**Person/day**)	0.47	1.12	0.001	0.001

Source: Ojoro, G.M. O, 2011

Transport expenses makes **33.2%** of household budget in outer zone and **21.6%** of household budget in inner zone (**Ojoro, G.O.M, 2011**), despite of these results being evidencing that rate of transport costs in central location is less than dispersed (outskirt) Locations within the Dar es Salaam City, it also tell that the urban transport within Dar es Salaam is too expensive and unaffordable. Victoria Transport Policy Institute Guidelines by **Litman, A.T. (2011)** on how to evaluate accessibility for transport planning and measuring people ability to reach desirable goods and activities rules that, any transport system requiring lower income households to spend more than 20% of their budget on transport is considered unaffordable transport system. Situations is too tough to poor and low income household, especially for those who are living below poverty line of Tanzania (**TZS.13,998.00** per 28 days) which is about 34% of Dar es Salaam citizens, (**NBS, 2007**) and those living in outer zone since the development of land and urban transport system makes it necessary to get all important human needs in CDB (Kariakoo and Posta) including work and Business Floors, For instance current Dala-dala fare per trip within Dar es Salaam City is TZS.300.00 (**SUMATRA, 2011**), and planned BRT fare TZS.500.00 per trip. This can be translated simply that go and return trip to work per head costs households TZS.16,800.00 per 28 days, nevertheless, informal settlements needs Boda-boda to access Public transit with average costs of TZS.1,800.00 per day (TZS.50,400.00 per 28 days) in sprawl and outskirt developments, so the main cause of the increased travel costs in Dar es Salaam is associated with uncontrolled land-used development.

Taking the facts that fuel costs is climbing every day and is not on our hand to able control, the only best alternative which is on our hand and we can control easy is Location of activities and household in connection with planning transport system to improve affordability and accessibility. This integration can be made as public transport oriented developments (ToD) to have our urban land plan on attention of affordability and connectivity for highest accessibility so that all our Public Transport systems in urban will rely on walking and cycling as the major feeding modes, while at the same time land-use development will be used to reduces travel demand by controlling activities locations and hence achieving sustainability (Reduced congestion, emission, increased accessibility to all and all, and increased equity).

It is opinion of this paper that if Land-use control will not be integrated with our urban transport planning then BRT patronage will be affected too in near future after operations.

Travel demand in Dar es Salaam households is higher in informal settlements and sprawl development (Outer zone) compared to inner zone, it seems that if we could be able to located just basic needs activities like market and shopping centres, Banking services, schools, health centres at walking and cycling vicinity we can cut down transport costs in Dar es Salaam by more than 50% from the current travel expenses. All these raise a question on the needs for land-use and transport planning integration for the sustainable system. Current demand distribution shows that majority of the household in Dar es Salaam is forced travel to CDB and Inner zone (88.2%) (**Ojoro, G.O.M, 2011**) despite of the facts that more 70% of citizens are living in Outer zone (**NBS, 2007**)

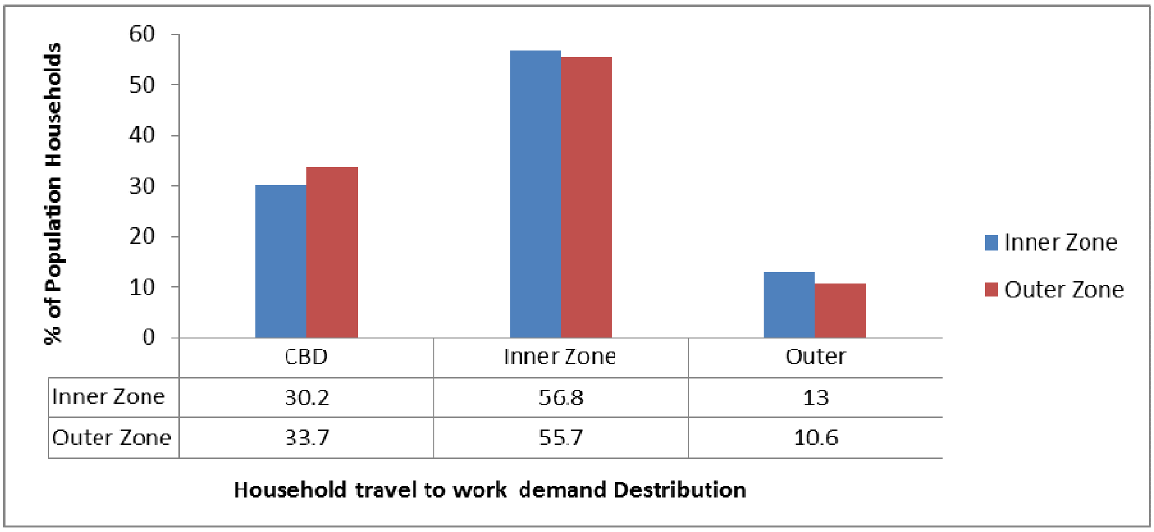

Fig. 0-1: Household Travel to Work Demand Destination

The use of motorcycle as transport tool **in Tanzania as public transport has increased between year 2006 and 2010, major causes of innovation of using motorcycle in urban areas is low ratio of road surface per development density, congestion and unemployment rate; motorcyclist took advantage of manoeuvre through traffic jam and penetrates to household within areas without road connectivity and as employment opportunity to vast majority of youths who does not have secured employment (**Ojoro, G.O.M, 2011**).**

Major challenges with Boda-boda are how to reduce accidents, control of associated transport impacts like noises, scrap of spare parts, reduce and control of emissions and increase socio-economic benefits and how to integrate Boda-boda into urban transport system especially BRT system for Dar es Salaam transport. SUMATRA **manager in Ilala Dar es Salaam** Johns, K [Interviewed] **indicated that SUMATRA is in a preparation of motorcycle regulations, which is in opinion of this paper that, it's of great importance if the draft regulations shall not focus only on revenue collection rather than major transport socio-economic benefits including, ownership, quality of motorcycles imported to Tanzania, Training of drivers and integration with public transport especially the working locations and accessibility management.**

Another transport problem associated with the land-use control in Dar es Salaam is **Poor accessibility to Bus stop from home** Figure 3-2 below points out modes used by Dala-dala users for access bus stops. Household in sprawl developments and informal are greatly depending on Boda-boda to access Dala-dala stops. This shows how land-use is influencing our transport system accessibility including travel expenses, interchange mode and time and shows importance land-use development control for the sustainable accessibility.

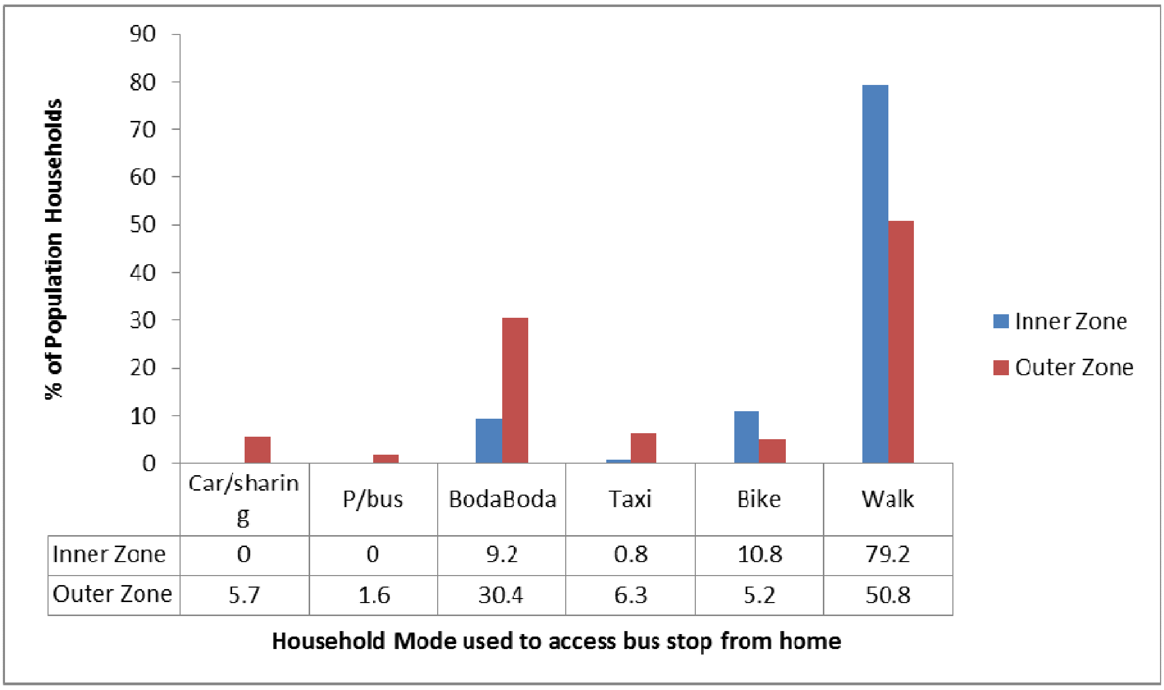

Fig. 0-2: Modes used to Access Bus stop.

4.0 DISCUSSIONS, RECOMMENDATIONS AND CONCLUSION

This paper has restrained itself into the assessment of the transport potentials that needs special attention for the integrated sustainable urban land-use and transport planning to enhance communities to benefit from the Public transport system like BRT system planned for Dar es Salaam and ensuring sustainable transport system is achieved in the Urban areas by increasing accessibility for all, reduce environmental impacts, and reduce inequality across the whole urban system.

There is direct easiness of integrating inner zone and planned areas to the Public transit system like Dar-BRT system than for outer zones, sprawl and informal settlements (Squatters) impending on the location of the zone which is within the network and households that are located closer to the bus stops and activities locations. Planners needs to set standard minimum distances from home bus stops, distance to necessary human needs activities, development types and standards and maximum distance and infrastructures for walking and cycling within our urban lands as the land-use development and transport planning indicators for success.

Orientation of the outer zone from the main road is limiting accessibility of people to use public transport and hinders transport sustainability and makes public transport unaffordable. Uncontrolled developments (Squatters/informal) are allied with lack of road connectivity and long travel distance from communities to activities centres, increases travel potential and increases car use.

Urban transport plans needs to considering total travel plan from home to the end of work trips for the all urban dwellers and integration with land-use development, instead of planning only arterial transport routes.

Growth of population, human settlements and activities are going ahead the Government urban land-development plans, residential settlements is spreading outwards and resulted into multiplying squatter development at outskirt, which in turn increases the travel distance, this orientation brings challenges on how these communities can be feed into public transit and it makes outer zone in Dar es Salaam to be poor oriented to public transport. If these outskirt developments will continue without control it will increase into more suburbanisation and growth of exurban settlements pattern which in future might lead to the hindrance of public transport patronage and encourage more and more car use.

Literature review and the studies indicates that relatively amount spent in transport increases as household income increases and travel potential increases, or share of transport decreases as income rises and transport potential increases and also transport demand never satisfied with the supply of infrastructures (**Button, K., et al, 1993 and Litman, A.T., 2011**), hence the best tool that will reduce private car use in sprawl development and reduce congestion and emission rates by reducing travel potential and necessary travel distance to shopping, markets, schools, and making connectivity within the urban land with sustainable modes of bike tracks and reduction of sprawl development is land-use control policies integrated with transport planning.

Boda-boda is current gives alternative transport to the passengers at disadvantaged accessibility in informal developments, so its regulation is important including special driving training program to Boda-boda drivers and enforcement for the use of safety helmet and reflective garments, quality, type and impacts of motorcycle engines in Tanzania against electric engines motorcycle.

Transport benefits behind the mass transit like Dar-BRT that replaces poor bus service like Dala-dala services is capitalised on travel time saving, reduction of congestion and hence reduction of greenhouse gases emission. (**Cain, A. et al, 2006**). This means BRT will depend on the following potential tools to meet its targets only at the advantage where these tools will work in synergy; Mode shift, route restructuring to remove some of the Dala-dala from the corridor and establish stable trunk-feeder operations, Bus Capacity (Large bus capacity, fewer buses will replace several Dala-dala), Segregated Bus lane (Reduce accidents by reducing collision chance), Head time and distance control and Smart bus specifications (EURO-3 specifications with less emission rate than Dala-dala), experiences shows that Land use change is of paramount, taking experiences from Latin America, the only way to make the system sustainable for reducing congestion and pollution impacts for long service is by **land-use restructuring** to have ToD system which reduce and orient demand for BRT use especially in outer zone where orientation hinders public transport usage. Boda-boda which is encouraged with poor planning and uncontrolled land-use if will not controlled can be barrier to growing Patronage to BRT use and Public transit. Current the use of Boda-boda for feeding public transit from informal development and land locked areas seem to be cheaper option, since it needs only traffic management measures without capital investment into infrastructure to serve squatter developments but its maximisation will be barrier to the patronage since its capacity to feed mass transit system is relatively impossible in terms of number of passengers it can transport to meet high occupancy transit demand (Like BRT), for instance Articulated BRT bus is planned to be 140-Pessenger capacity which mean to feed it full will need running about 140 Boda-boda from outskirt to the bus stop at once, and to meet planned BRT demand of 13,000 passenger per hour per direction means very large number of motorcycle operations, not only it can lead to empty running of BRT buses but it will mean more pollution and noise in household streets if it will be engaged as the only mode to feed BRT system at outer zone.

5.0 RECOMMENDATIONS

Based on the study findings, results implications and discussion the following recommendations are given by this paper: -

5.1 An integrated Dar es Salaam Land-use and transport planning.

Low cost regularization and restructuring of the outer zone informal developments to have walking and cycling routes connecting households and bus stops with minimum possible infrastructures connectivity will ensure sustainable feeding to BRT and reduce transport costs to the citizens and eliminate bottleneck to feeding the system depending on Boda-boda only, cars and feeder buses. Integrated land-use and transport planning seems necessary in order to address the growing problem linked to urban transport, land-use and accessibility to bus stop from outskirt communities, through greater control of land-use and design over a larger area of the urban land. This also can overcome the incapacity of small scale, road reserve encroachment problem and ad-hoc uncoordinated developments to create well planned, attractive liveable environment that will encourage walkability and cycling to the bus stops. land-use developments control will minimise the need for travel and reduce trip lengths then demand for car use will be reduced and reduce transport expenses and encouraging people to leave their cars behind. Restructuring of informal development and integration of land-use and transport planning will create well neighbourhood including reduced travel distance and offer benefits on reduced road need, less infrastructure costs and saved user costs.

5.2 Regulation of the Boda-boda transport and set policy for its operations.

If control of the Boda-boda operations are properly done taking the advantage of the accessibility to Public transit bus stop at cheap price it will enhance sustainability at earlier stage when government is building capacity for restructuring of informal development and integration of policies for land-use control and transport planning, and in later planning it serve peripheral areas of the urban to near villages.

5.3 Institutional arrangement.

There are several transport institutions dealing with urban transport in Tanzania but are not properly coordinated, it's possible in Tanzania to find a building within the road reserve in accordance to Road Act, which has all necessary building permits and land title from land authority and councils, building and activities in cities and towns which are totally or partially closes street or public land.

Integrated land-use and transport planning policies may integrate major urban transport institutions and assist well in avoidance of problems like development encroachments into road reverse, nullifying of land titles within the road reserve.

One specialist transport institution for the urban is required in Tanzania. It's that institution which can successfully implement land-use and transport planning integration. This paper propose Government to charge one institution with Urban Land-use and Transport planning with ability to control and plan transport system of all cities and towns.

5.4 Implement BRT in stage (Incremental) instead of waiting for the full package while situation is worsening.

BRT scheme was planned to start operations on 2009, but up now construction of infrastructures is lagging behind the schedule. Worse thing is that there is nothing is done for the transport system of the Dar es Salaam, congestion problem is worsening and transport system is deteriorating without any strong measures in place because authorities and institutions are waiting for the BRT and master plan to mature, with some infrastructure improvement approach which is dealing with increase of supply without control of Demand.

BRT project can be implemented incremental by adding features in time instead of waiting for the full package, this could have enabled objective comparison across the package tools but also allocation of funds to the project and achieve greater benefit at lowest costs.

Study by **Nile, J. and Jerram, C.L, (2010)** shows that YORK region in southern Ontario North of Canada implemented York regional VIVA BRT in three incremental phases started in 2005. Phase-1: implementation was institution of high capacity buses, priority treatment, improvement of feeder routes, schedule improvement and extensive branding and marketing, in year 2005. Second increment followed in 2009 called VIVA next included dedicated lane infrastructure construction and last increment is planned depending on future ridership to light rail on the dedicate way used by BRT. **Nile, J. and Jerram, C.L, (2010)** found in their research that incremental implementation of VIVA BRT allowed transport planners to improve transport service and address congestion problem in the near term while establishing the issue of right of way and building ridership support.

Los Angeles, Metro BRT and Orange line BRT is another evidence of the successful incremental implementation of the BRT, Metro Rapid incremental strategy started with improvement of signal priority, high occupancy buses, headway base schedule, less frequency stops, and colour code, then followed with dedicated bus lane, off-vehicle fare collection and feeder network. BRT is fundamentally incremental (**Ibid**).

Dar es Salaam BRT have bundles of characteristics which can be subjected to incremental implementation at cheaper costs to rescue the situation of transport system in Dar es Salaam, for instance DART may procure Buses for feeder system and run them on phase-1 using bus lane, priority roads/gates with improved intersections and pedestrian crossings this will avoid sudden phasing out Dala-dala from the system.

5.5 Employees and Schools Travel Plans to be integrated with Urban transport system

Integrated travel plan with urban transport system will assist in demand management for instance more than 68% of the car users in Dar es Salaam get free office car park spaces (**Ojoro, G.O.M, 2011**).

Further investigation may be done to establish the number of private car users who are using employer's vehicles, and how it can be integrated with the Transport.

5.6 Promote Walkability within Urban Lands

All Bus users are automatically pedestrians at the both ends of the journey to carter for the informal development and CBD effects to patronage on public transit use a bundle of tools for encouraging walking at travel ends are needed in our urban including implementations of Pedestrian Boulevards in zones like Karikakoo, Pedestrian only streets in some areas in CDB and Universities, Parks and Public spaces at outer zones and central zones and walking lanes with street lights.

5.7 Review Parking Policy for Demand Management

For instances DCC is using Parking for revenue generation instead of demand management. There is a need for Planners to review the parking policy under urban transport regulations to control demand including free parking at offices and travel plan integration.

6.0 CONCLUSIONS

This paper determines that Urban Population growth and income increases are among contributors of the urban sprawl and informal developments in the outskirt of the Tanzania urban areas. Structure of the outer sprawl development households is very different to that of the central households in terms of income, car ownership and travel expenses. Travel potential in informal and squatter developments is higher, high travel cost, high distance to work, high distance to bus stop and high distanced land-use activities.

The higher potential for travel has makes Sprawl developments to be car oriented and increased Boda-boda dependency. Rate of car use is also higher. Sprawl development Land orientation is also hinder sustainable modes like cycling and walking to bus stop. School children have to go to school using special pre-planned school buses which guarantee them door to door service. Unless special transport planning consideration is made particular for informal developments on how to integrate outskirt household with the Public transit system to increase patronage these households will take time to leave their cars home and use Public transit system due to the feeding problem and interchange, our urban transport system needs synergy tools to encourage maximum use of walking, cycling and public transit modes. An integrated transport and land use policies implemented with the mass transit system incrementally is of paramount for the sustainable transport of our cities and towns.

Paper is therefore concludes that informal development in Dar es Salaam and uncontrolled location of activities affects the accessibility and patronage of the public transport bus usage with increased use of Boda-boda transport, which will also hinder BRT usage especially patronage, unless the communities in sprawl developments will be integrated with the BRT system to reduce the effects of sprawl and enhancing affordable, effective and efficient interchange modes of transport and land-use control that avoids informal developments and enhance effective feeder system and improves accessibility to all, our cities will still face transport disadvantaged and increased congestion and accidents.

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DEPOSITION OF METAL POLLUTANTS ALONG ROADSIDES IN DAR ES SALAAM

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ABSTRACT

The fast increasing traffic in cities is considered as one of the major contributors to pollution. This study was done to establish the presence and concentration of metal elements along roadsides at various locations in Dar es Salaam. A geographical distribution of the study points was established considering special features like traffic density and surrounding land use and existing infrastructure close to the sites. The samples were digested in aqua-regia solution, dried, filtered and then diluted to required concentrations for analysis. Metal concentration was determined using the Atomic Absorption Spectrophotometer (AAS) machine. The results generally showed higher levels of lead (Pb) followed by chromium (Cr) and then copper (Cu). Zinc (Zn), and nickel (Ni) were mostly found to be in comparatively much lower concentrations. Cadmium (Cd) was practically non-existent in almost all locations that were tested. The results show trends similar in other cities in the world where most of the pollutants originate from the traffic. The high levels of lead seem to suggest a potential risk from motor vehicle emissions. The planning of the city infrastructure therefore needs to take into consideration the associated dangers of theses pollutants given the inevitable increase in traffic activity in the future. Further, wider and more detailed studies are required to ascertain the trends and possible distribution of the pollutants.

1.0 INTRODUCTION

Automobiles are considered among the major sources of particulate pollution around the world (Faiz et al. 2009); (Harrison et al., 1981; Gibson and Farmer, 1986; Soyhan et al., 1999) quoted by Sezgin et al. (2003). Other sources include emissions from industries, power stations, construction activities, natural weather phenomena (wind, typhoons, tornadoes etc.) various combustion processes and many other natural and man-initiated phenomena. The presence of heavy metals in the emitted or settled particulate matter is of particular concern due to the serious health effects of these elements. The most common heavy metals include Cadmium (Cd), Copper (Cu), Lead (Pb), Nickel (Ni) and Zinc (Zn) (Faiz et al. 2009). For a long time now Lead has been the most prominent heavy metal deposited along roadsides. The reason for this is the long practiced tradition

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(since the 1920s) of adding Tetraethyl- and/or tetramethyl lead to petrol to improve the Octane-number. Normally, the presence of the heavy metals in the top soil along roadsides is an indicator of the pollution thereof. The deposition of the emitted heavy metals depends on the particle sizes. The finer particles below 5 microns will travel longer distances from the edge of the road while coarser particles above this size will mostly be confined within 1.5 m from the edge of the road (Sezgin et al. 2003).

Exposure to heavy metals is known to cause a variety of health problems to humans. Even low level of lead exposure is believed to interfere with certain enzyme functions and may cause brain damage and bring about behavior change. Prolonged exposure to Cadmium Cd may affect a variety of organs including the kidneys. Further, acute exposure to Cu dust or fumes may cause metal fume fever with symptoms such as cough, chills and muscle ache. Nickel is said to have the potential to cause skin rashes and other disorders.

Studies conducted elsewhere in the world have yielded results shown in Table 1

Table 1: Heavy metal concentration in urban road dusts from various cities in the world (Shi et al., 2008)

S/N	**CITY**	**Pb**	**Zn**	**Cu**	**Cr**	**Cd**	**Ni**
1.	Birmingham	48.0	534.0	466.9	-	1.62	41.1
2.	Coventry	47.1	385.7	226.4	-	0.9	129.7
3.	New York	2582	1811	355	-	8	-
4.	London	2100	539	108	-	2.7	-
5.	Hong Kong	181	1450	173	-	3.77	-
6.	Madrid	192.7	476	188	-	-	44
7.	Seoul	245	296	101	-	3	-
8.	Taejon	52	214	57	-	-	-
9.	Honolulu	106	434	167	273	-	177
10.	Oslo	180	412	123	-	1.4	41
11.	Bahrain	697	152	-	72	126	-
12.	Hamilton	214	645	129	-	4.1	-
13.	Christchurch	1091	548	137.4	-	1	-
14.	Lancaster	1090	260	75	-	3.66	-
15.	Ottawa	33.49	101.3	38.13	41.7	0.33	14.8
16.	Urbana	1000	320	-	-	1.6	250
17.	Shanghai	294.9	733.8	196.8	159.3	31.23	83.98

Various methods have been employed in the determination of heavy metals in the environment. Oetvoes et al. (2003) for instance have analyzed mosses to study the level of heavy metals in the environment.

The authors have not been able to locate any studies in Tanzania related to heavy metal deposition originating mainly from the motor vehicles. Available information ……….

shows that the number of motor vehicles is increasing constantly and it is projected to increase even at a faster rate in the coming years. It is to be expected therefore that pollution associated with heavy traffic will increase and with it the associated health problems. It is therefore imperative that studies are carried out on the extent and nature of the problem. This paper presents an initial study carried out to identify the type of heavy metals found along roadsides as well as the concentration and geographical distribution around Dar es Salaam.

2.0 MATERIALS AND METHODS

2.1 Study area

The study was concentrated in areas commonly considered to have high traffic density. A lot of roads in Dar es Salaam are known to have heavy traffic for the largest part of the day. The study was designed to cover most of the roads that have this characteristic. Geographical distribution was also given consideration in the selection of the data collection points. The roads that were selected therefore included Mandela road, Morogoro road, Uhuru road, Nyerere road and the New Bagamoyo road. A few other roads that are known to have lower traffic density were selected for the purpose of comparison. These included Msasani in Msasani Peninsular road and Masaki in Haille Selasse road. Ubungo Bus Terminal was included in the study area to get a comparison of the area that is mostly occupied by stationary buses that idle for most of the time.

2.3 Sample collection

Soil samples were collected at about 1 m from the paved surface of the road and at a depth not exceeding 4 cm from the surface. The top surface was scratched to remove loose sand soil and a scoop was used to get the sample from each point. To avoid bias, sampling was done from three points. About 100 g were collected from each point which were then stored in sealable polyethylene bags that were labeled accordingly.

2.4 Sample preparation and analysis

The samples were dried at a temperature of 105 ℃ to constant weight. The dried samples were then ground in a ball mill for 1 hr and sieved at 435 µm. The samples were then split and representative sample weighing 1 g was obtained from the lot. Aqua regia solution was prepared from hydrochloric acid and nitric acid in the ratio of 3:1. The prepared sample was mixed with 5 ml aqua regia and stirred with a glass road. The mixture was heated on a hot plate at a temperature of 165 ℃ to 195 ℃ to dryness. The dry sample was cooled to room temperature in a desiccators. A 100 ml of distilled water was added and then the suspension was filtered using filter paper in a funnel placed on a volumetric flask. 0.2 ml of the filtrate was taken and diluted to 20 ml in a test tube and thereafter quantitative analysis was done using the AAS machine.

2.5 Results and Discussion

2.5.1 Elemental Concentration for Different Roads

Fig. 1 shows the concentration of different elements for samples taken within the road boundaries for a number of roads in Dar es Salaam. The figure also shows the type of elements actually found in these roads. From this study Lead, Zinc, Chromium, Copper and Nickel have been found to occur along roadsides in Dar es Salaam. Lead has been found to have the highest concentration in all the roads shown in Fig. 1. It is also seen that the highest concentration of Lead (5.5 mg/l) is found along Morogoro road followed by Nyerere road (4.8 mg/l). Uhuru road has depicted the lowest concentration of lead in the soil. Morogoro road is probably the road with the highest traffic density in Dar es Salaam. It is used more by smaller cars that are more likely to be running on petrol. The presence of Lead in the highest concentration is probably expected considering that for a long time Tetraethyl Lead has been added to petrol to improve Octane rating.

In contrast, the highest concentration of Chromium has been found along New Bagamoyo road followed by Nyerere and Morogoro roads in that order. The values for Chromium are all less than 2 mg/l. Copper is next in the list in terms of the available concentration. It has been found to be less than 1 mg/l in all cases shown in this figure. Ni seems to be negligible from this study.

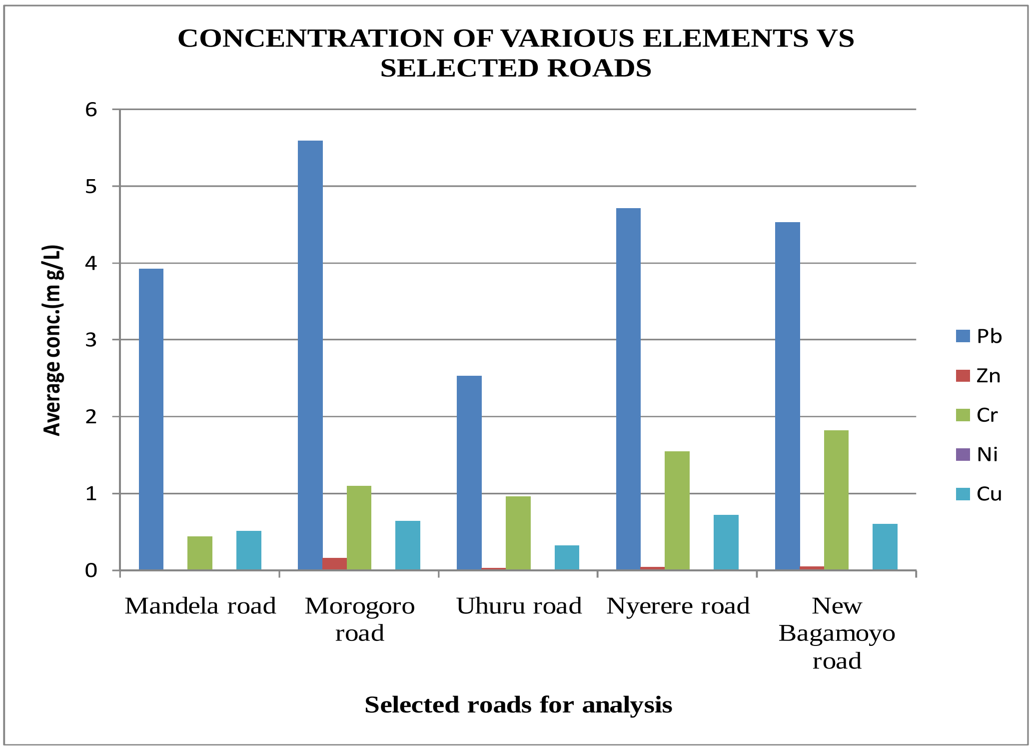

Fig. 3: Concentration of different elements on a number of roads in Dar es Salaam

2.5.2 Elemental Concentration from Other Sources

Fig. 2 shows concentration of elements from points outside the road boundaries and from sources other than pure roadside. It is generally observed that the concentrations are relatively higher (up to 21 mg/l) compared to tests conducted on samples from inside the road boundaries (Fig. 1). Masaki area seems to have taken the lead followed by the city centre. Lead is still the leading element in these areas. Nickel that was almost negligible within the road boundaries, is now found in relatively significant concentrations on the roadsides. Masaki area is known to have relatively higher number of industries operating in the area. It can not be ruled out that the industries have contributed to the concentration of lead in the soil from this area.

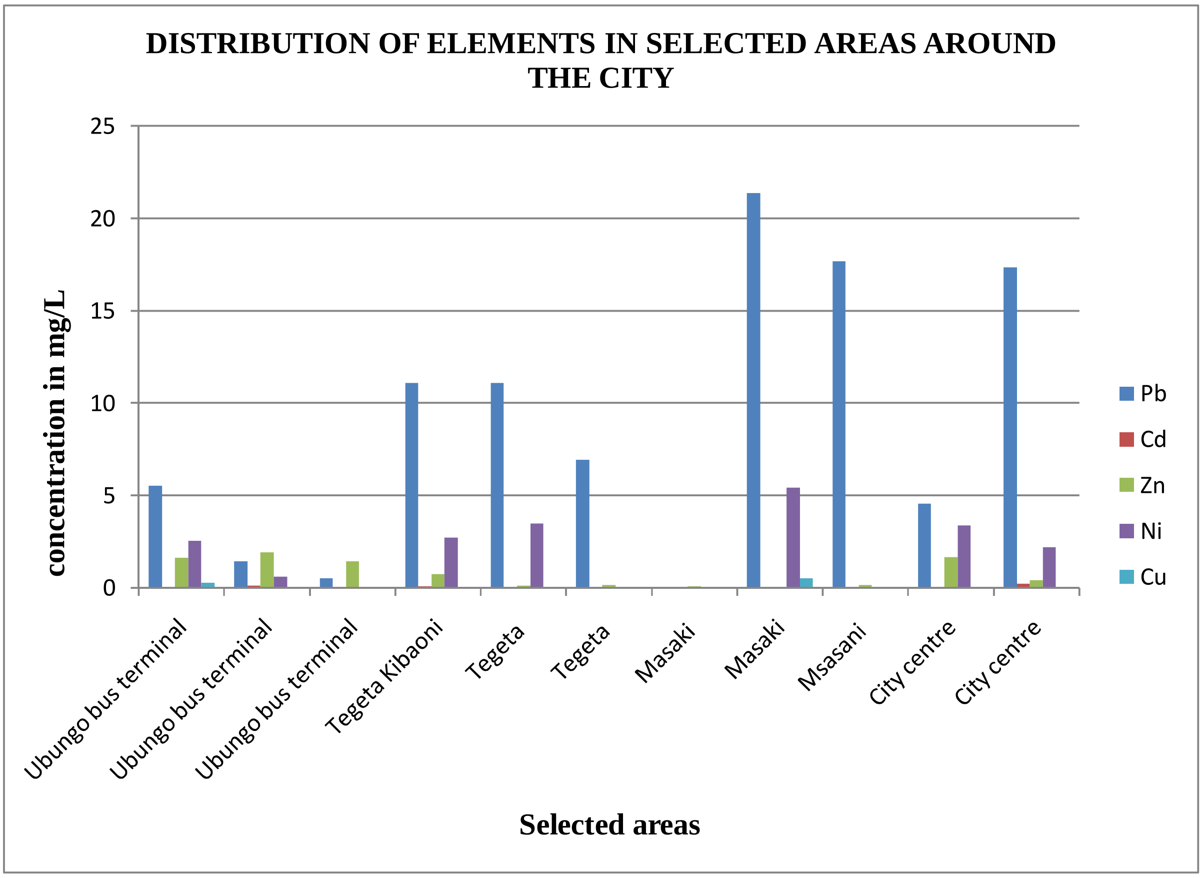

Fig. 4: Elemental concentration from other sources

3.0 CONCLUSION

The study shows that there could be a building up of concentration of elements along our roads that so far has gone almost unnoticed. Lead is found to have the highest concentration in all cases that have been considered. The study is not offering conclusive distribution of these elements.

4.0 RECOMMENDATION

Further study is needed to define clearly the pattern of the distribution of the elements.

5.0 ACKNOWLEDGEMENT

The authors wish to acknowledge the contribution of Andalu Frida in this study. They also wish to thank SIDA/Sarec for their generous financial support that made this study possible. Further, they extend their gratitude to the technicians who carried out the analysis in the laboratory.

6.0 NOMENCLATURE

AAS	Atomic Absorption Spectrometer
CFC	Chlorofluorocarbons
FAAS	Flame Atomic Absorption Spectrometer
GST	Geological Survey of Tanzania
GPS	Global Positioning System
NEMC	National Environmental Management Council
PM	Particulate Matter
VOC	Volatile Organic Compounds

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ROAD TRAFFIC ACCIDENTS: RESCUE AND EXTRICATION

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ABSTRACT

Road traffic accidents present fire fighters, medics and rescue crews with a greatest challenge. Usually there are multiple victims, often more than one of these is seriously hurt, may be with life threatening injuries. The responsibility to get these casualties out of their vehicle and into a trauma centre sits squarely on emergency services and at times inexperienced public who come to the rescue lacking extrication tools. In order to accomplish this important mission, we must fully understand the dynamics of extrication at the scene. To execute this mission-extricate these people as quickly and safely as possible- we must have a clear understanding of extrication strategy, tactics and tools.

The majority of those who die in motor vehicle accidents are invariably trapped. Over 50% of car user fatalities die pre-hospital in the first hour or succumb in the following four hours at the hospital. The quest for having Rescue standards in place and improving survivability through post impact rescue and trauma care is paramount and requires realistic preplanning (i.e. Dynamic risk analysis and safety in extrication, and coefficient pre-hospital care practices).

1.0 INTRODUCTION

In my line of work I have been fortunate to visit countries in all four corner of the globe either in rescue mission or for education of the emergency services. In countries like the USA and in Europe , Emergency services are held in high regard and they are considered an asset to the community. In other countries like ours they are perceived as the bottom of the food chain and their work rarely receives recognition for performance under horrific condition.

Road traffic accidents (RTAs) in Tanzania alone causes an average of 3400 deaths per yea rand 20000 serious injuries. The real tragedy is that up to one third of all trauma deaths may be preventable. This statistics is based on the fact that a large proportion of these deaths are from blocked or restricted airways.

Severe congestion in Cities, a total ignorance of approaching emergency vehicle, and an unbelievably heterogeneous traffic system combine to make fast response and safe arrival at an incident almost unattainable. The response times are long and it may take two hours to reach an accident 30Km from station.

Securing the scene and creating a safe working environment is impossible. There can be anywhere from 500 to a thousand onlookers and would be helpers and thieves at a large incident and they are impossible to control.

2.0 SAVER

Most European countries have a standard approach to manage traffic collisions, such as the SAVER method. SAVER stands for systematic approach to victim entrapment rescue and is a multidisciplinary approach to rescuing injured casualties from various situation and delivery the casualty to the hospital within the golden hour. SAVER is divided into seven phases.

Phase 1 **Approach**: Response and safe arrival

Phase 2 **Risk and stabilization**: Secure the scene and provide a safe working environment for the rescue crews and casualties.

Phase 3 **Gaining access**: Access the casualties

Phase 4 **Trauma care**: Provide medical care.

Phase 5 **Creating space:** Safely extricate casualties from wreckage if required

Phase 6 **Extrication**: Remove to the nearest medical facilities in a similar or better condition than when the rescue started.

Phase 7 **Evaluation and Practice**: Make up and debrief.

During each phase a standard set of operating procedures laid down by each different participating emergency service are followed. In USA or European environment these phases are achieved relatively easily as traffic system are specifically designed to assist emergency response, traffic is homogenous and crowds respect the orders of the police and other EMS crews.

3.0 VEHICLE ENTRAPMENT

As RTA deaths are increasing, the levels of survivability of the entrapped vehicle occupants a increase and consequently, the number of entrapments remain s high. The challenge now, is for rescuers to extricate casualties safely in time and with care. The importance of adapting the rescue plan according to the condition of the casualty cannot be over emphasized. The extremes of extrication range from dealing with a casualty trapped in a car on fire to an extrication where the casualty is stable, but has a very high index of suspicion of spinal injury.

The "GOLDEN HOUR" concept still applies to any major trauma and every effort should be made to deliver the casualty to definitive care as quickly as possible, by effective professional rescue, but without causing any further injury. I believe this is where extricating speed within the correct extricating plan together with a high quality of casualty care.

The kinematics and the mechanism of injury; involved in the collision need to be recognized. These massive forces can cause spinal injury, but more usually cause massive internal hemorrhage, due to internal collision, which result in shearing or compression injuries to organs, such as the liver or spleen. These injuries can normally be treated through surgery.

4.0 INTER-SERVICE CO-OPERATION

Unfortunately, emergency services do not train together very often. This can create difficulties at operational incidents if there is a lack of understanding when problem occur. These difficulties are often due to the fact that our respective roles sometimes create conflict, i.e. such circumstances as using hydraulic tools whilst working in the vehicle at the sometime that critical medical interventions are being carried out or the moving of vehicles for rescue purposes, which consequently may destroy the police evidence for accident investigation.

These difficulties between the services may prove detrimental to the casualty on occasion, by creating an unnecessary delay in extrication. There is a moral and legal obligation for all emergency service personnel to ensure that the services provided to entrapped casualties is the best possible. This can only be achieved by developing a team approach and ensuring that all personnel involved in the pre-hospital treatment of RTA casualties receive team training on a regularly basis in addition to maintaining their skills. All personnel as part of a team response will play an important role in the drive to reduce mortality, rates from trauma.

Extrication training should cover three main areas:-

1. Incident command and safety.
2. Trauma management and extrication and
3. Physical rescue.

5.0 PRE-HOSPITAL CARE

It is imperative that all emergency service personnel can administration basic, but good quality, pre-hospital care such as airway management, C-spine control and the delivery of 100% oxygen at 15 liters per minute, in the absence of professional medical care or when faced with a multi-casualty situation such as a coach, train or aircraft incident.

The physical and medical rescue plan need to be discussed between the fire and emergence crews to ensure the correct method of extrication is chosen. Options need to be formulated and planned for in the event of the rapid deterioration of the casualty, physical rescue crews should not promise unrealistic and over ambition extrication times to medical staff in attendance. If the incident is going to be prolonged then the ambulance crews request BASIC doctors etc.

6.0 CASUALTY EXTRICATION

There are many techniques for extricating casualties from vehicles. Many pre-hospital courses; extrication and medical publication demonstrate some of the suggested techniques. There appears to be no agreed national best practice yet although the Fire Service is working on a draft plan towards what will be the nationally agreed protocol on the extrication of casualties.

There are several recognized pre-plan for extrication; immediate, rapid and controlled. Therefore it is imperative that all rescue personnel are aware of the rescue plan that has been agreed and also the “time window” (in Minutes) that the crews are working to (see also Annex A)

Immediate is where the casualty needs to be out of the vehicle urgently. This may be due to a medical condition such as an arrest or a compromised airway that cannot be addressed in the vehicle or where chemicals or fire are involved etc.

Rapid release is the extrication of a time-critical casualty within 5/10 minutes of the arrival of the rescue services. This is where the minimum of cutting is made and the casualty is extricated speedily, but with as much spinal consideration as the situation allows. The egress is often through a “side out” a door or the hatch, but often with the roof still in place. It has to be recognized that the casualty’s other serious injuries take a degree of precedent over potential spinal injuries.

There are at least eight different ways removing the casualty from the vehicle in a rapid scenario, the method used is often dictated by the doors and space that is available, the position and injuries of casualty and the time frame. However the principle remain that an airway and manual in-line immobilization of the C-spine is maintained, hi-flow O2 is administration and as many rescuers as the space allows move the casualty’s head, chest, pelvis and legs in unison, whilst supporting the casualty and maintaining manual in-line immobilization. Several C-spine “hand-overs” are normally required during the removal or turning of the casualty. In the case of every extrication consideration needs to be given to the casualty’s injuries.

Controlling releases is where a large amount of space is made quickly around the casualty, sufficient to allow a minimum of 5 rescuers (one head person and two each side of the casualty, plus one on the board if available) to extricate the casualty from the vehicle. The extrication needs to be modified to take into account the casualty's position and the scenario faced.

7.0 EMERGENCY CARE ACTION PLAN

In medical emergency it is necessary to have an action plan, one that will work every time, regardless of the type of incident. The following action plan is called DRABC each letter stands for something the rescuer must do, and the sequence in which it will be done.

The following chart sets out the DRABC action plan composing:

D - Danger R – Response A – Airway B – Breathing C – Circulation, the chart also shows the order of priority and the appropriate time for the control, of bleeding and the care of the unconscious casualty.

Check for danger to:- Yourself The casualty and Bystanders Act only if safe to do so: Do not become the next casualty Remove danger from the casualty, or if Necessary the casualty form danger Warn bystanders of any danger and ask them to keep a safe distance. If unsafe, wait for expert assistance to arrive.	D – Danger
Check for response: Gently shake and shout loudly. If the casualty responds, check and control serious External bleeding. If no response, proceed with ABC	R - Response

First place casualty on side, then: Open the mouth Clear if needed, and keep the airway open (head tilt and jaw support)	A – Airway
Look, listen and feel: Is the lower chest or the abdomen rising and Falling? Can you hear breathing sounds? Can you feel breathing?	B - Breathing
Then: If the casualty is breathing but not responding place onto side , or if the casualty is not breathing, start expired air resuscitation (EAR)	
Check the carotid neck pulse: If present, continue EAR. If absent, start cardiopulmonary resuscitation (CPR) **Note:** These procedures apply to a casualty outside of vehicle. Considerable improvisations may have to be implemented for the casualty trapped inside a vehicle.	C - Circulation

THE BASIS TO EXPLOIT COMPRESSED NATURAL GAS IN TRANSPORT: TOWARDS LESSENING PUBLIC EXPENDITURES IN TANZANIA

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ABSTRACT

This paper examines the scope of rising public expenditures due to transport costs and efforts to reduce it. Transport costs in East Africa are aggravated by ever-increasing price of petroleum in the world market. The paper selects analyses natural gas as the best alternative energy in propelling transport motive powers in Tanzania. It aims at determining the amount of public funds savings resulting from the use of compressed natural gas in public service vehicles based in Dar es Salaam.

Natural gas in the form of compressed natural gas (CNG) is important in transport sector as the combustion of gasoline and diesel results in emission of noxious pollutants. It cost less than gasoline and diesel where there were 11.2 million natural gas vehicles as at 2009 worldwide.

The price difference between natural gas and conventional fuels has often been regarded as the most important factor of attracting users to switch to CNG vehicles. The findings of this paper are of great importance to the government budget as they provide the best alternative to save tax-payers money that can be channeled in poverty alleviation programs. As the country is marking its 50th anniversary of independence the paper recommends the nation to migrate from fossil oil to compressed natural gas as a major national fuel for the next 50 years in effort to truly alleviate poverty in Tanzania.

1.0 INTRODUCTION

Since independence, Tanzania has been tackling three major development problems; ignorance, diseases and poverty. In doing so Government expenditure has been on the increase in an attempt to get rid of the problems. Transport service, which plays a crucial role in the growth of the Tanzanian economy i.e. it facilitates domestic and international trade, contributes to national integration, and provides access to jobs, health, education and other essential facilities have been increasingly a major uncompromising cost component of Tanzania Government expenditure.

East Africa is feeling the knock-on effects of the sharp rise in global crude oil prices which could hurt economic projections. Analysts say economic growth in Kenya, Uganda, Tanzania, Rwanda and Burundi is threatened by inflation driven by the escalating cost of fuel as countries in the region are net importers of petroleum products, Senelwa (2011). "The price increases have been caused by a rise in the petroleum products prices in the world market and depreciation of the Tanzanian shilling compared to the US dollar - the currency in which purchases of products in the international oil market are made, Masebu, (2011).

Retail prices for various products as on August 15th 2011, have increased as follows: Petrol TZS 110.34 (or 5.51%), Diesel TZS 120.47 (or 6.30%) and Kerosene TZS 100.87 (or 5.30%). For instance, during this period, the exchange rate has changed by TZS 47.12 (or 2.96%), whereas the Cost Insurance and Freight (CIF) costs have increased by an average of 5.42%. A comparison of prices computations using the old formula and the new formula with regard to retail prices is as follows:

Table 1: New Increased Fuel Price in Tanzania

Product	**Retail Price (TZS/L)**		**Wholesale Prices (TZS/L)**	
	Old Formula	New Formula	Old Formula	New Formula
Petrol	2,298.33	2,114.12	2,230.07	2,046.62
Diesel	2,213.36	2,031.31	2,140.80	1,963.81
Kerosene	2,188.89	2,005.40	2,116.33	1,937.90

Source: Energy and Water Utility Regulatory Authority (EWURA)

It is quite clear therefore that the main drivers for petroleum price movements continue to be the world market prices as well as the exchange rate of the Tanzania shilling against the US dollar. In line with the prevailing sector legislation, prices of petroleum products are governed by rules of supply and demand.

Table 2: Oil imports vs. Total imports in Tanzania

YEARS	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Imports, Goods & Services, US$	2,209.7	2,143.9	2,659.2	3,457.6	4,204.9	5,113.4	6,274.3	8,661.2	7,543.2	8,974.7
Oil Imports US$	200.9	177.3	367.0	575.0	847.3	1,146.5	1,462.1	1,922.2	1,323.0	1,983.8
Oil Imports/Total Imports bills % p.a.	9.09	8.27	13.80	16.63	20.15	22.42	23.30	22.19	17.54	22.10
Average for Five years	13.59					21.51				

Source: BOT: Economic Bulletins (2001 – 2010)

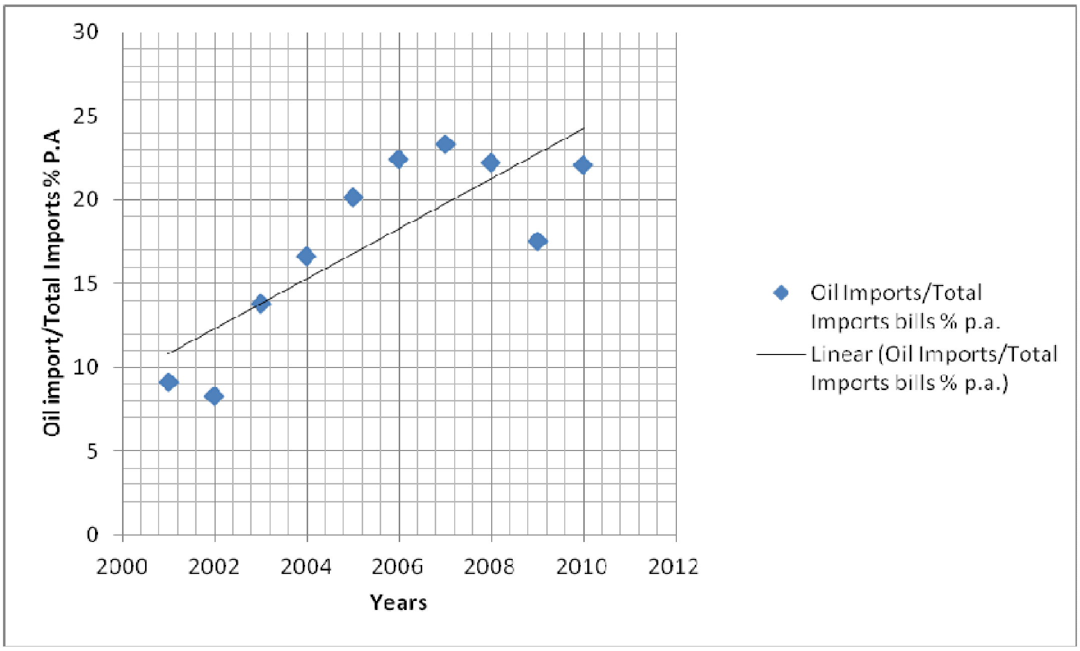

Fig. 1: **The Percentage Average Trend of Oil Imports over Total Import Bills**

Table 2 and Figure 1 compare the Oil imports to total imports in Tanzania for the period 2001 -2010. Both indicate that oil import bills have been increasing at an increasing rate with a decrease in year 2009 during the global economic crunch. On average in the last five years oil import accounted for more than 21%.

Table 3(a): Government Budgets, 2006/2007- 2010/2011

	2010/11	2009/10	2008/9	2007/8	2006/7
Recurrent Expenditures	7,790,506	6,688,254	4,726,650	3,866,000	3,116,121
Public Debt/CFS	1,756,044	1,523,024	648,284	615,000	287,786
Ministries	4,155,768	3,476,243	3,083,867	2,358,000	2,037,536
Regions	119,580	123,013	85,743	83,000	60514
Local Government Authorities	1,759,114	1,565,974	908,756	810,000	730,285
Development Expenditure	3,819,051	2,825,431	2,489,480	2,201,000	1,734,467
Total Expenditures	**11,609,557**	**9, 513,685**	**7,216,130**	**6,067,000**	**4,850,588**

(b) Recurrent and Development Expenditures

Financial Year	**2006/7**	**2007/8**	**2008/9**	**2009/10**	**2010/11**
Recurrent Expenditures	**3,116,121**	**3,866,000**	**4,726,650**	**6,688,254**	**7,790,506**
Development Expenditure	**1,734,467**	**2,201,000**	**2,489,480**	**2,825,431**	**3,819,051**
Total Expenditures	**4,850,588**	**6,067,000**	**7,216,130**	**9,513,685**	**11,609,557**

Source: Ministry of Finance and Economic Affairs

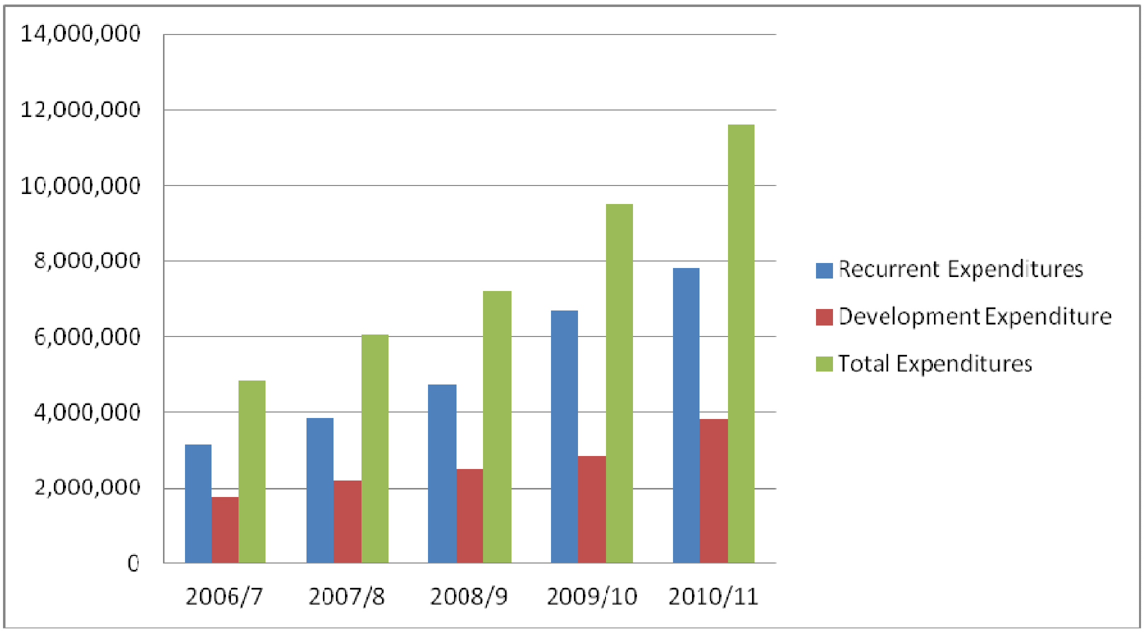

Fig. 2: Government Expenditures (in Millions)

Table 3(a) and (b) both show the increase in Government expenditures, where Figure 2; illustrates the relationship between recurrent and development expenditure increase in Five Financial years 2006/7 -2010/11. Comparing data in table 3 to table 2, it clearly indicate that there is relationship between oil price increases to the increase in both recurrent and development government expenditures.

Piracy in Indian Ocean results in several types of economic costs to the shipping industry, including ransom payments, damage to ships and cargoes, delays in cargo deliveries, increased maritime insurance rates, and costs to harden merchant ships against attack. Some of these costs are ultimately passed on to the consumer. The total economic costs of piracy, though large in an absolute sense, are nevertheless only a small fraction of the total value of worldwide shipborne commerce, Ploch et al.; (2011)

This study therefore, was conducted in order to establish the amount of money which can be saved once the Dar es Salaam based government vehicles can start using the Compressed Natural Gas. The CNG will also reduce the amount of harmful exhaust emissions produced by the petrol- and diesel-engines. Thus it aimed at determining the amount of savings in shillings that can accrue from the use of compressed natural gas instead of petroleum fuels (diesel and gasoline) for motor vehicles owned by central, local government and all public institutions based in Dar es Salaam.

1.1 Why Alternative Fuels?

The fundamental problem is that the international petroleum market does not allocate oil resources in a socially efficient manner. It does not account for large environmental impacts, and it is volatile and politicized, distorting energy decisions through inappropriate price signals and uncertainty. Four major problems and costs are not captured in market prices:

a) Energy security (dependence on insecure petroleum suppliers.)
b) Indirect economic costs of importing energy
c) Global warming
d) Urban air pollution.

1.2 Transport Energy Futures

According Sperling and Deluchi (1989) transport energy futures indicate that substituting an alternative fuel for 2 million barrels per day of gasoline fuel, thereby reducing world oil demand, would lower the world oil price by about $2 per barrel when oil is priced at $34 per barrel. If this analysis is correct, those 2 million gasoline-equivalent barrels would reduce the import cost of oil to the United States by about $18 million per day ($6.6 billion per year), or $9.00 per gasoline-equivalent barrel of alternative fuel-. The benefit of suppressing short-term oil price spikes may be even larger, because the spikes may be steeper and more disruptive. If oil-importing countries wait for higher prices, they will not be able to respond with alternative fuels for many years. High prices could be maintained for 10 years or more as the United States and other oil importers struggle to expedite the transition to non petroleum fuels and replace vehicles that consume only gasoline and diesel fuel.

1.3 Rising Oil Imports

Impose large indirect costs on the national economy, since the outflow of funds to pay for imported oil shrinks demand for domestic goods and services. This cost is difficult to estimate because it depends on hard-to-assess factors such as how much the exporting nations reinvest their earnings in the United States, what they invest in, the response of exchange rates to changes in terms of trade, and employment in the United States exporting industries. In any event, it has been estimated that the Macroeconomic external costs of rising imports may run as high as $50 per barrel of oil. Thus, even though they cannot be accurately quantified, indirect economic costs are another motivation for introducing alternative fuels.

1.4 Global Warming

The third problem, global warming, is caused by increasing atmospheric concentrations of carbon dioxide and other "greenhouse gases," many of which are produced by the combustion of coal, oil, and natural gas; it is now attracting much more attention than energy security or indirect economic impacts, partly because its potential costs are much greater, although more speculative.

Transportation is a large source of greenhouse gases: As scientific evidence becomes more certain, the possibility exists that a strong commitment will be made to reduce the use of carbon fuels. It is unlikely that carbon dioxide emissions could be reduced economically by adding control systems to vehicles or refineries. The most feasible strategy for reducing carbon dioxide emissions from transportation is less consumption of fossil fuels, either by increasing fuel-efficiency or using non-fossil energy sources, such as biomass, hydrogen made from water with non-fossil electricity, or electricity made from non-fossil fuels (primarily solar, nuclear, or hydroelectric power).

The price of crude oil increase trend in the world market

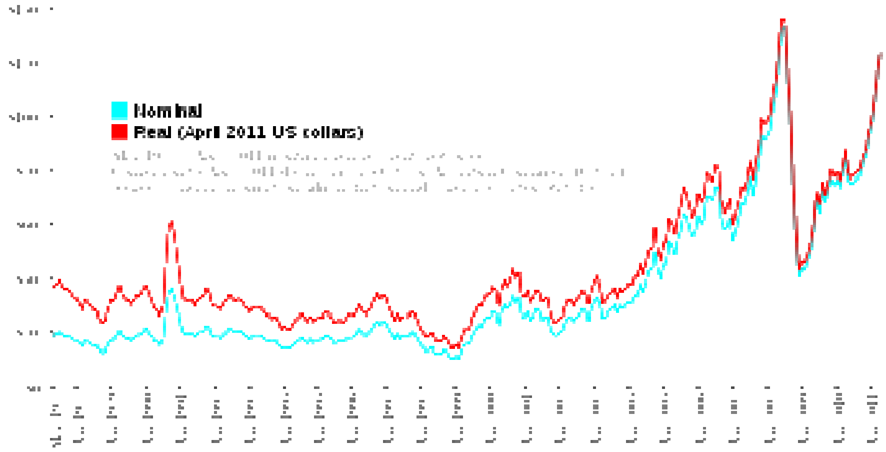

Fig. 3: Oil price Brent Barrel

Brent barrel petroleum spot prices, May 1987 – April 2011. Due to exchange rate fluctuations, the real price line is only relevant to the United States and countries with a currency tied to the U.S. dollar at a constant rate throughout the period.

The demand for oil is highly dependent on global macroeconomic conditions. According to the International Energy Agency (IEA), high oil prices generally have a large negative impact on the global economic growth. The IEA has a broad role in promoting alternate energy sources (including renewable energy), rational energy policies, and multinational energy technology co-operation, Sperling and Deluchi (1993).

As the demand for fuel nowadays rapidly increase according to the industrial development all over the world the stock of fossil fuel reduces very fast. CNG one of the alternative fuels is really important to support the transportation sector. Currently, most of the CNG engine vehicle is a converted version whether from the diesel vehicle or gasoline vehicle. To widespread the use of CNG, the refueling network must be established all over the country within the CNG engine vehicle driving range and at the same time the refueling technology and the dedicated CNG engine vehicle technology must be improved. This is very important as preparation of the gas-age (when the fossil fuel totally out of resource).

1.5 Natural Gas in Transportation

Natural gas has long been considered as an alternative fuel for the transportation sector. In fact, natural gas has been used to fuel vehicles since the 1930's.

According to the statistics, there are currently 215,000 (114,000 running by LPG and 101,000 by CNG) Natural Gas Vehicles (NGVs) on the road in the China up to 2004, and more than 4 million NGVs worldwide. In recent years, technology has improved to allow for a proliferation of natural gas vehicles, particularly for fuel intensive vehicle fleets, such as taxicabs and public buses. Most natural gas vehicles operate using compressed natural gas (CNG). This compressed gas is stored in similar fashion to car's gasoline tank, attached to the rear, top, or undercarriage of the vehicle in a tube shaped storage tank. A CNG tank can be filled in a similar manner, and in a similar amount of time to gasoline tank.

1.6 Malaysian Scenario in CNG as an Alternative Fuel

The growth of vehicles number in Malaysia is quite high. In year 2005, 1.02million new vehicles were registered and 55% of new registrations were cars. At certain state the number of vehicles is more than its population. For example in Penang, there were 1.47 million vehicles compares to 1.4 million populations. This contributed to the more demand on fuel usage and air pollution increased. This kind of situation has happened all over the world hence the need for alternative fuel, like CNG becomes obvious. As the price of CNG worldwide is very much lower than petrol and diesel; it is 40 – 50% of petrol and diesel price it also reduces the maintenance cost when CNG engines are compared to the existing engines.

The Malaysian government has implemented a few components to encourage the use of CNG as alternative fuel included.

(i) Ensure the continuous availability and fair pricing of the CNG. The current price of CNG is RM0.68 per liter. Compare to the petrol and diesel the price of CNG are lower 65% and 57%.

(ii) Additional reduction of the road tax from existing level
   a) Monogas or dedicated vehicles 50% off
   b) bi-fuel vehicles 25% off
   c) dual fuel vehicles 25% off

(iii) Tax incentives and other financial incentives for encouraging and facilitating for purchasing new buses, other vehicles and construction of CNG outlets

The commercialization of CNG vehicles in Malaysia is far behind compare to other countries like Argentina, Brazil and Pakistan. Currently, there are 40 service stations in Malaysia, providing CNG refueling facilities to a population of around 15,600 natural gas vehicles.

The important component to encourage the usage of CNG in Malaysia are developing CNG dedicated engine or using the available CNG dedicated engine in the market, provide a nationwide natural gas infrastructures, develop the political willingness to revise existing law and regulation across disciplines, agencies and government, ensure the availability and fair pricing of the CNG, for the city bus, the routes and ridership must be established and create tax incentives or instruments for encouraging and facilitating new bus purchases and fuel station built-out.

International Agreements on the greenhouse gases (GHG), such as the Kyoto Protocol, Gothenburg and UNFCCC, signed by many countries, emphasize on a need for all countries to take immediate action to reduce emission of the greenhouse gases, and industrialized countries to help the developing countries to finance the projects which aim at reducing emissions of these gases. One of such projects is the CNGV technology, which involves use of compressed natural gas (CNG) to fuel vehicles instead of the traditional petrol and diesel fuels. It is also believed that the technology can be suitable for Tanzania, especially because natural gas is produced locally at the Songosongo and Mnazi bay gas fields, making it cheaper than the traditional fuels which need foreign currency for importation.

1.7 Natural Gas Development in Tanzania

Currently there are two proven Natural Gas Reservoirs discovered in Tanzania. The first one is Songosongo Natural Gas Field with a proven deposit of about 1 TCF while the second being Mnazi Bay Natural Gas Field with almost the same estimated deposit of about 1 TCF. The two fields are located on Southern Coastal belt of Tanzania.

Fig. 4: showing the location of the Natural Gas fields on Tanzania

The Songosongo Natural Gas Field has been developed and the production started on July, 2004. Current the production is about 32.5 MMscfd, out of this 28 MMscfd is used by Ubungo Power plant for generation of 105 MW, electricity and 3.5 MMscfd is used by Wazo Hill Cement plant. Later on the production will be increased to 36 MMscfd to meet the signed contract by Tanzania Electricity Supply Company and Wazo Cement for about 20 years. This will lead to increase in electricity production to meet the demand. The construction design is to produce 41 MMscfd of Natural Gas and transport it to Ubungo-Dare es salaam 225km through 16"diameter pipeline for the power generation and other industrial and domestic users.

The Mnazi Bay Natural Gas Fields is under development, when it is complete, it would be in a position to produce almost same amount as Songosongo Gas Fields of about 41 MMscfd. The gas produced from this field will mainly be used in Dar es Salaam; The Government of Tanzania through its Five Years Development Plan 2011/12 – 2015/16, contemplates to embark on a 30'' natural gas project from Mnazi Bay to Dar es Salaam in the first twelve (12) months of the plan. This will increase the natural gas supply in Dar es Salaam and reduce further the price of natural gas to the end users.

1.8 Data Analysis

The study aimed at establishing the amount of money, which can be saved from public expenditures once governments in Dar es Salaam decide to exploit compressed natural gas in transport. Therefore, the study had first to establish how much diesel and gasoline is consumed by motor vehicles currently owned and run by central, local governments and all public institutions based in the Dar es Salaam region.

Table 5: Diesel Consumed by Government vehicles in Dar es Salaam

	As at August 3, 2011; current Price - 2031.31 TZS		
	Years	Diesel consumed in Lts	Current Value in TZS
		Per Financial Year	
1	2005/6	5,678,481	11,534,755,240.11
2	2006/7	4,941,624	10,037,970,247.44
3	2007/8	4,877,345	9,907,399,671.95
4	2008/9	4,047,165	8,221,046,736.15
5	2009/10	5,176,150	10,514,365,256.50
6	2010/11	6,192,580	12,579,049,679.80
	Total	**30,913,345**	**62,794,586,831.95**

Source: Government Procurement Services Agency (GPSA)

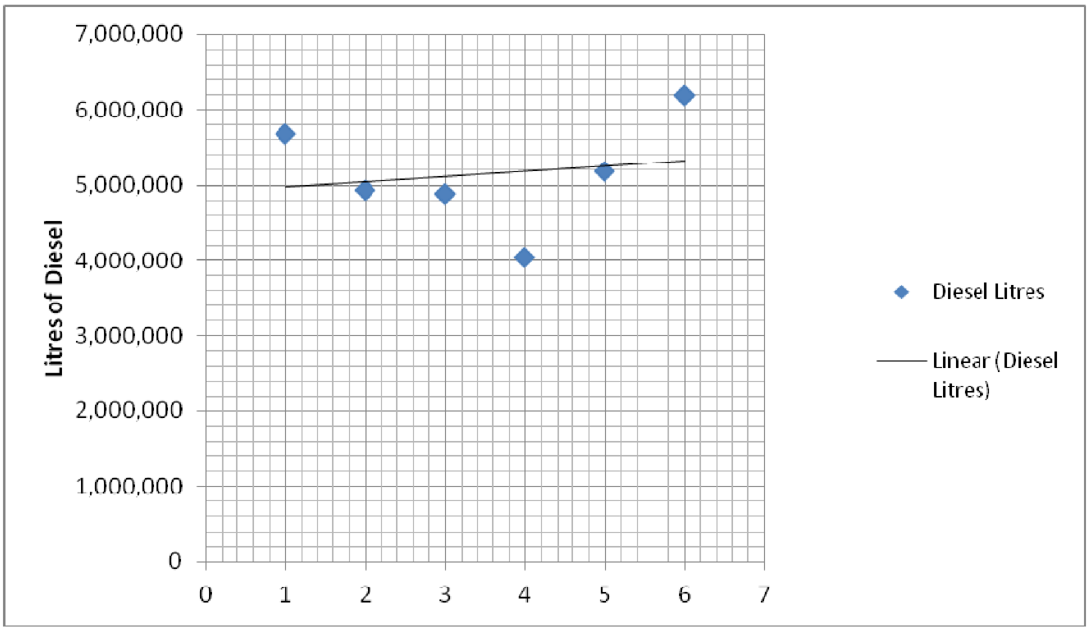

Fig. 5: The Average Trend of Diesel Consumption

From table 5 and figure 5: the conservative assumption made is that the market price of diesel will remain constant throughout the period of next six years i.e. 2011/12 to 2016/17 and the rate of diesel consumption will remain the same, thus government vehicles in Dar es Salaam will consume diesel worth **62,794,586,831.95 TZS** only in six years. If these vehicles will be converted to Compressed Natural Vehicle (CNV) the fuel cost will as follows:

The cost of natural gas is 40 – 50% of diesel price,
Therefore;

a) At the lowest price of natural gas:
   40% x 62,794,586,831.95 = 25, 117,834,732.78 TZS
   Savings from the price of diesel:
   62,794,586,831.95 - 25,117,834,732.78 = **37,676,752,099.17** TZS
   In six years less the cost of converting vehicles.

b) At the highest price of natural gas:
   50% x 62,794,586,831.95 = 31,397,293,415.98
   Savings from the price of diesel:
   62,794,586,831.95 - 31,397,293,415.975 = **31,397,293,415.975**
   In six years less the cost of converting vehicles

The savings in fuel will be between **37,676,752,099.17** and **31,397,293,415.975 TZS**

Table 6: Petrol Consumed by Government vehicles in Dar es Salaam

	As at August 3, 2011; Current Price - 2114.12 TZS/Lt		
	Years	Petrol consumed in Lts Per Financial Year	Current Value in TZS
1	2005/6	437,234	924,365,144.08
2	2006/7	404,800	855,795,776.00
3	2007/8	397,255	839,844,740.60
4	2008/9	325,512	688,171,429.44
5	2009/10	491,404	1,038,887,024.48
6	2010/11	625,729	1,322,866,193.48
	Total	**2,681,934**	**5,669,930,308.08**

Source: Government Procurement Services Agency (GPSA)

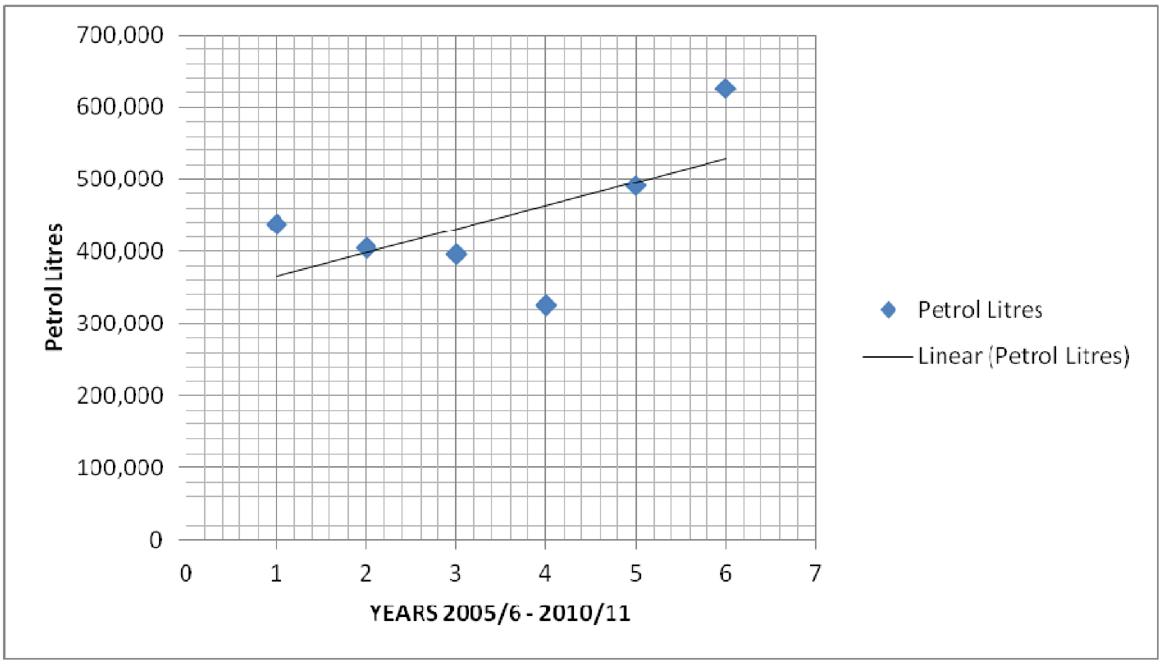

Fig. 6: The Average Trend of Petrol Consumption

From table 6 and figure 6: the conservative assumption made is that the market price of petrol will remain constant throughout the period of next six years i.e. 2011/12 to 2016/17 and the rate of petrol consumption will remain the same, thus government vehicles in

Dar es Salaam will consume petrol worth **5,669,930,308.08 TZS** only in six years. If these vehicles will be converted to Compressed Natural Gas Vehicle (CNGV) the fuel cost will as follows:

The cost of natural gas is 40 – 50% of diesel price,
Therefore;

a) At the lowest price of natural gas:
40% x 5,669,930,308.08 = 2,267,972,123.232 TZS
Savings from the price of petrol:
5,669,930,308.08 - 2,267,972,123.232 = **3,401,958,184.848 TZS**
In six years less the cost of converting vehicles.

b) At the highest price of natural gas:
50% x 5,669,930,308.08 = **2,834,965,154.04**
Savings from the price of petrol:
5,669,930,308.08 - 2,834,965,154.04 = **2,834,965,154.04**
In six years less the cost of converting vehicles

The savings from petrol will be between **3,401,958,184.848** and **2,834,965,154.04 TZS**

However, from figure 5 and 6, both trends depicts that the amount of diesel and petrol to be consumed in litres will increase at an increasing rate, hence predicting that the government will spend more on oil imports in the next six years than what it has spent in the past six years. Therefore, if the government will go for compressed natural gas suggested it will save more than the sum of money arithmetically demonstrated above.

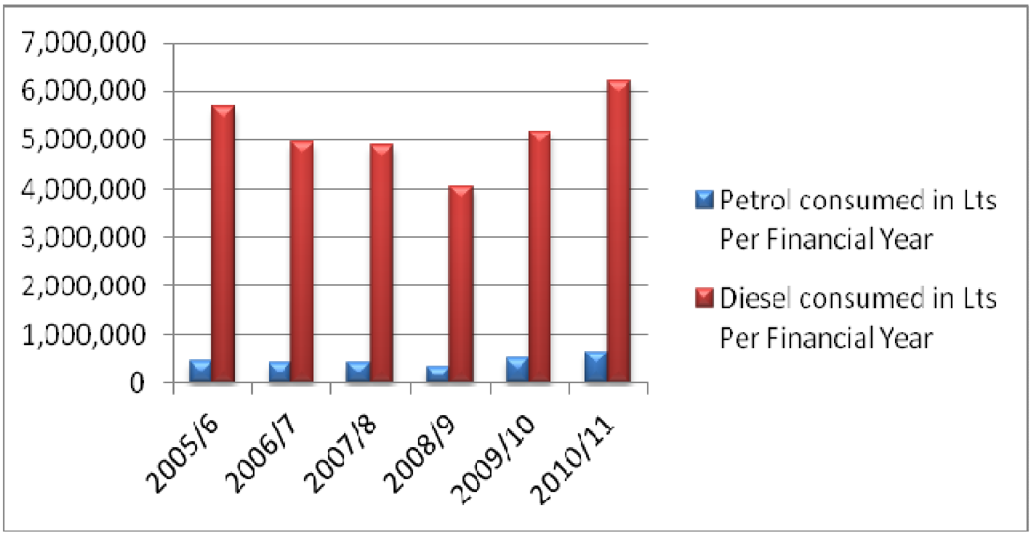

Fig. 7: Diesel and Petrol Consumption Volumes

The government in Dar es Salaam is mainly using diesel vehicle for its day to day activities as there is less volume of petrol consumed in the last six years. This can be related to the price of petrol while compromising other factors like air pollution and price of diesel vehicles.

Recently, the Tanzania Petroleum Development Corporation (TPDC) has prepared a plan to implement an alternative fuel program for all state fleet vehicles. The plan will make it mandatory for government vehicles to be configured in order to use natural gas. According to Mwamnyange, (2010), using natural gas over other traditional fuels like charcoal, petrol, diesel, liquefied petroleum gas and heavy fuel oil will save the government more than 36.62Million US$ in oil products import every year. In meantime the conversion of vehicles to use natural gas is being carried out at two centers by private companies working with government institutions. Furthermore, the benefits of using natural gas are immense. “Even the environment and forests are targeted in the master plan, as less carbon dioxide and carbon monoxide will be released into the atmosphere.”

However, besides having the conversion centers in place and the natural gas filling station for the last two years, vehicle conversion has recorded not more than forty (40) private cars and non – state vehicle.

Fig. 8: CNG Filling Station in Dar es Salaam - Ubungo

Tax revenues: the Tax Revenue Authority has been enjoying easy fuel tax collection. This can constrain the idea of not using imported oils and convert vehicles into CNV. However, from arithmetic calculations it has been proved that the foregone tax for 171 vehicles using petrol will be recovered through the unused foreign exchange money in settling oil import bills and earn a net saving of **367,906,618.28 TZS**

Table 7: Taxes Foregone Vs Import Bill forex

VEHICLES	
Taxes Forgone	
VEHICLES	171
Litres/day	10
days/year	365
Litres/year	624,150
Tax rate	539
Tax foregone in Tsh	336,416,850
Tax foregone in $	224,277.90
Forex Saved	
CIF - Petrol (US$)	989
Conversion litres/MT	1359
Conversion US$/Tshs	1600
VEHICLES	171
Litres/day	10
days/year	365
Litres/year	624150
CIF/litre	0.727740986
Forex Saved in $	454,219.54
Forex Saved in Tshs.	726,751,258.28
Net Savings (usd)	229,941.64
Net Savings (Tsh)	**367,906,618.28**

Calculated taxes foregone against import bill saved in foreign exchange

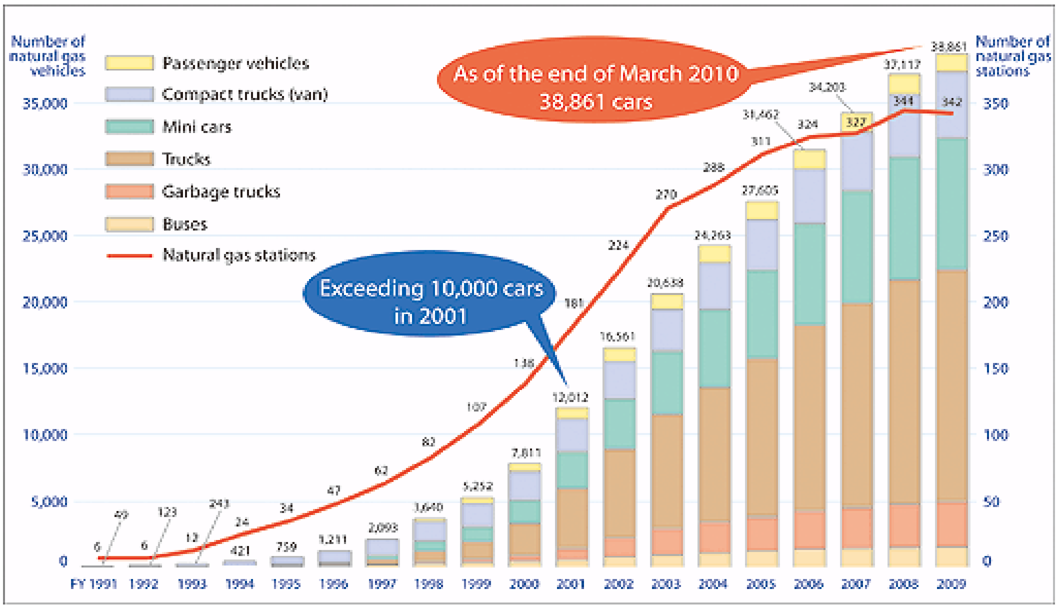

Fig. 9: The Japan Experience in CNV Usage

1.8 The Challenges

1) Lack of Refueling stations:
   a) Most of petrol vehicles can travel up 480 kilometers or more on a tank of fuel. When they run low, they pull into gas station to fill up.
   b) Typically, NGV can go about the same distance i.e. Dar –Dodoma. However, when they run out of fuel there is no place to fill up
2) Availability of CNG parts: There is some fear that there are no CNG parts. This can easily be eliminated because the technology is widely used World-wide.
3) Research and Development: Research and development activities in Tanzania are too weak. Researchers need to research on NGV materials extensively.
4) CNG use in transport promotion encounters drawbacks from fossil oil profit making traders in Tanzania

2.0 CONCLUSION AND RECOMMENDATIONS

The paper concludes that Natural Gas Vehicles in Tanzania urgently need to be promoted very much, it will easy the ever increasing public expenditure that is attributed by ever rising transport costs. With the very conservative assumption of minimum estimation the Dar es Salaam based government vehicle the combined savings will range between **41,078,710,284.018** to **34,232,258,570.015 TZS** from the price of diesel and petrol alone. The economy will be able make foreign exchange net saving from oil import bills of **367,906,618.28 TZS** per year for not importing petrol and use to alleviate poverty. The paper calls upon all government stakeholders in Dar es Salaam to act immediately in implementing the Natural Gas Vehicle Conversion project so as to realize the calculated savings while protecting the environment and enhance poverty alleviation in the country.

Notwithstanding, the paper recommends the nation to shift from fossil oil dependence to compressed natural gas as a major national fuel for the next 50 years in effort to alleviate poverty.

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ICT AS A TOOL FOR DEVELOPMENT OF TRAFFIC CONTROL SYSTEMS

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ABSTRACT

The application of Intelligent Transportation Systems (ITS) in Intelligent Traffic Control System (ITCS), is expected to improve the performance of road transportation significantly. Public policy makers, among others, are therefore increasingly interested in the implementation possibilities of these systems. However, current knowledge ITS implementation issues is poor with respect to technological requirements for its implementation. The contribution of ITS to general transport policy goals and the willingness of stakeholders to accept and use it is still low. This paper gives an overview of ongoing research at University of Dar es Salaam, on the role of ICT in Traffic Control Systems.

Key words: *pre-timed, adaptive logic, networked controller, cycle length, phases.*

1.0 INTRODUCTION

Transportation practitioners and researchers alike realized that road building can never keep pace with the increasing demand for travel. Many countries in the world who invested a lot in building road networks and infrastructure, and are now facing the challenge of revitalizing this huge network and making the best use of its already existing capacity before expanding further. Though there is another set of driving forces which is environmental related activities in the sector of transport, such as traffic emissions which has risen to an alarming levels. In all industrial countries, for instance, transport represents the single largest source of greenhouse gas emissions, accounting for 27 percent of the total emissions, which is estimated to increase to 42 percent by the year 2020. The problem is even greater in more car dependent societies where the escalating death tolls and injuries in traffic accidents each year are third set cause of death. For all these reasons, more road building is not always viable or desirable. Computer technologies is set to offer one attractive and promising approach, and hence the ITS. A healthy ITS industry would also have other non-traffic related society benefits, including stimulation of new information technology based industries and creation of new markets and jobs. Therefore, ITS is more than just intelligent solutions on the road. It is a new strategic direction for national and international economies.

2.0 LITERATURE REVIEW

Intelligent Transport Systems (ITS) combines transport technology and information systems, communication, sensors, and iteration methods with the surface transportation infrastructure. In addition to technological and systems issues, there are institutional issues that must be addressed. At some stage, government is required to implement ITS as an integrator of transportation, computer networks and communications systems in order to apply the system as a solution for transport problems in modern (Sussman, J. M., 1996).

Rush-hour conditions in cities are often extended throughout the day. Further, safety problems abounded, particularly highway safety. Also, city residents are concerned with the environmental impacts of transportation and the energy implications. Due to these compounded transportation problems, the need of new initiatives in the surface transportation emerged, taking into account social economics, environmental and energy issues. In addressing the social economic problem due to transport problems, ITS emerged .

2.1 ITS Basics

ITS can stand on four pillars

- *(i) Data entry and collection points, which involves sensors which the presence and identity of vehicles in real-time on the road through roadside devices or Global Positioning Systems (GPS).*
- *(ii) Communication and Networking points which collects the data and information transmits them through computer network.*
- *(iii) Signal conditioner and process elements which receives transport data and process them.*
- *(iv) Traffic information use and display device which outputs the information in a real-time in order to achieve better transportation network operations.*

By combination of logical and physical architect, the strategies for computer network control solution are developed. These architects compel one to think about road infrastructure and vehicles as a system, rather than independent components. One important attribute of ITS is that it is no longer restricted to civil engineers or to a single department or agency. Given the broad range of technologies involved, the ITS field is multidepartmental, multiagency, and multijurisdictional, cutting across the public, private, and academic sectors. This broadness certainly is enhancing potential, widening scope, and revolutionizing the way transportation systems are handled. It is also posing institutional challenges that must be prepared for taking ITS architecture in the transport network systems (Abdulhai, B., Kattan, L., 2004).

2.2 ITS Categories

ITS could either enhance the utilization of existing roadway capacity or increase capacity itself. Enhancing the use of existing capacity could be achievable through improved distribution of traffic, dynamically sending traffic away from congested roads to effectively utilize the road network, and the elimination of bottleneck causes at intersections and bus-stops.

Increasing the physical capacity could be possible through

- *traffic control automation.*
- *traffic coordination.*
- *elimination of the human behavior element which are detrimental to smooth flow of traffic.*

This is the promise of ITS that could potentially increase the number of vehicles which a road can handle.

From this perspective, ITS could be divided into two main categories of systems.

- *Traffic management and traveler information systems (TMIS).*
- *Vehicle control and automated highway systems (VCS and AHS).*

(i) TMIS

TMIS provides: -

(i) Extensive traffic surveillance and data acquisition.

(ii) Assessment of recurring congestion due to repetitive high demands, and detection of nonrecurring congestion due to incidents.

(iii) Traffic information and route guidance dissemination to drivers.

(iv) Adaptive optimization of control systems such as traffic signals.

The current trends in TMIS relies on centralized management in traffic management centers which gauge traffic conditions by receiving information from vehicle detectors throughout the network as well as the vehicles themselves. TMIS formulate control measures in the center and disseminate control to field devices as well as information and guidance to drivers. Newer trends of distributed computing control are emerging but have not crystallized yet. The main distinguishing characteristics of TMIS are real-time operation and network-wide multijurisdictional implementation.

(ii) VCS and AHS

VCS provide better control of the vehicle itself, either by assisting the driver or by automating the driving process in an auto-pilot-like fashion in order to increase capacity and enhance safety. Full automation of traveler information systems can result in higher speeds at lesser headways, and hence higher lane capacity. Automation can be applied to individual vehicles as free agents in a non-automated mix of traffic or as fully automated lanes carrying platoons of electronically linked vehicles. Although traveler information systems is technically promising, an array of unsettled issues remains, including legal liabilities in the event of incident due to any potential automatic controller failure, technical reliability issues, and social issues. Therefore, globally, traveler information systems is still underutilized at the current stage of ITS. The feasible alternative, however, is to use the technology to assist the driver, who remains in control of the vehicle that is, to make the vehicle smarter. Such intelligent vehicles will detect obstacles on the road, the blind spots and warn the driver accordingly, maintain constant distance from the vehicle ahead, and alert a sleepy driver who is going off the road. As technology improves further, the role of the intelligent vehicle can move from a simple warning to full intervention and accident prevention by applying the brakes or overriding faulty steering decisions.

The prime distinction between TMIS and VCS is that TMIS focus on smoothing out traffic flow in the network by helping the driver make best route-choice decisions and optimizing the control systems in the network, while VCS focus on the driver, the operation of the vehicle, and traffic maneuvers in the immediate vehicle vicinity. VCS focus on enhancing the driver’s awareness and perception, aiding decision-making by providing early warning and potentially initiating action, and eventually using sensory inputs and computer control in place of human sensory reactions and control.

2.3 ITS Architecture

ITS Architecture is comprised of the logical architecture and the physical architecture, which satisfy a defined set of user service requirements. As the ITS is still growing, different research groups are pursuing its development. There is a risk of investing and adopting ITS technology and equipment locally. Similarly, if left without adequate guidance, ITS systems solutions could only be directed to local needs, which might be incompatible with global systems. For instance, an in-vehicle navigation system purchased in one country might not work in another country. Therefore, to ensure seamless ITS operation, some sort of global or national system architecture and related standards are needed. To maximize fully the potential of ITS technologies, system design solutions must be compatible at the system interface level in order to share data, provide coordinated area-wide integrated operations, and support interoperable equipment and services where appropriate (Nagatani, T. 2002) . An ITS architecture provides this overall guidance to ensure system, product, and service compatibility or interoperability without limiting the design options of the stakeholder. There are two types of architecture namely logical and physical architectures’

2.4 Logical architecture

The logical architecture defines the processes by activities and functions that are required to provide the required user resource sharable services. Many different processes must work together and share information to provide a user service. The processes are implemented via software, and hardware. The Logical Architecture is independent of technologies and implementations.

The logical architecture consists of processes, data flows, terminators, and data storages. Data flows identify the information that is shared by the processes. The entry and exit points for the logical architecture are the sensors, computers, human operators of the ITS systems. These terminators appear in the physical architecture. Data storages are repositories of information maintained by the processes. The logical architecture is presented via data flow diagrams, or process specifications.

2.5 Physical Architecture

The physical architecture which represents ITS interfaces, consists of two layers which are: -

(i) A transportation layer that identifies the transportation systems and the information exchanges that support ITS, and

(ii) A communication layer that identifies the communication technologies and systems that support the information exchanges.

The transportation layer forms a high-level structure around the processes and data flows in the logical architecture. The transportation layer defines the physical entities (subsystems and terminators) that make up an ITS. It defines the architecture flows that connect the various subsystems and terminators into an integrated system. The subsystems generally provide a rich set of capabilities, that would be implemented in different stages. Equipment packages break up the subsystems into deployment sized pieces (Hamisi, N. Y 2010, Nagel, K., and M. Rickert. 2001).

3.0 INTELLIGENT TRAFFIC CONTROL SYSTEMS (I.T.C.S.), CASE STUDY – DAR ES SALAAM

ITCS being one of the fundamental of the user resource sharable services described by UN. The surveillance, control, communications, and support system activities covered from the basic framework upon which many of the other user resource sharable services depend. ITCS provides the real-time transportation network performance information, which many of the other Intelligent Transportation Systems (ITS) services use. In particular, the data collected, processed, and used by ITCS are also needed virtually by all of the other services in the Travel and Traffic Management Systems, as well as various services in the Public Transportation Management and Emergency Management Systems (FHWA, 2007).

ITCS gathers data from the field, converts it into usable information, and uses it to assign right-of-way to users of the transportation infrastructure. The basic goal of ITCS service is to maximize the efficiency of people and goods movement through the road network. If implemented properly, it helps to alleviate congestion problems, and improve air quality. ITCS information are also disseminated to the general public and other service providers, laying the foundation for many other user resource sharable services.

Closely related services that can be used in conjunction with ITCS is to provide overall transportation management such as:-

- *the incident management.*
- *travel demand management.*
- *electronic payment services.*
- *weigh bridge services.*
- *public transportation management and*
- *emergency vehicle management.*

3.1 Traffic control signal

In Dar es Salaam, the emergency of traffic control signals was in early 1970. Around the world, the control of traffic at intersections by lights dates back to 1913 in Cleveland, Ohio - United States. The current format of three lamps showing red, yellow and green dates back to 1918 in Detroit and New York in United States. In the UK, the first manually operated signals were installed in 1925 in London and the first automatic system was installed in 1926 in Wolvethampton. Since then, traffic signals have become all pervasive, successfully regulating traffic in all major cities (Bell, M.G.H). The Manual on Uniform Traffic Control Devices (MUTCD) provides specific warrants for the use of traffic control signals. These warrants are detailed and is justified by the significant cost and impact of application of traffic signals as compared to other control devices (McShane et al. 1998). Traffic volume represents the key factor in the Manual on MUTCD warrants. Other factors, such as pedestrian volume, accident data, and school crossing, also play a significant role (Garber and Hoel 2002).

In Dar es salaam, where the modeling of traffic control signal study is conducted, the traffic flow data were collected manually and by a detector on a section of the road. The collected data involves (Nagatani, T. 2002):-

- *traffic volume*
- *speed of vehicles and*
- *road occupancy*

The mix of road users was considered as an important aspect of signal control design because, it varies not only from location to location within a city, but also from district to district. For example, in Buguruni, Manzese, Tegeta and Mbagala Areas, the problem is to control a large number of moving and parking public vehicles, alongside pedestrians, trucks, taxis and private cars. By contrast, in the City Centre, the problem is typically to control a large number of private cars and pedestrians alongside a limited number of buses. In other area of the City, the problem was typically to control a large number of small public and private cars, trucks and pedestrians alongside a limited number of buses at the intersection. The road user groups considered here are: cars and trucks; buses cyclists and pedestrians'.

The specific objectives were to properly simulate, and then place traffic signals to.

1) *Assign sequentially right of way by computer network, which in turn could*
2) *Increase capacity*
3) *Eliminate conflicts, thus reducing severity of accidents at intersections*
4) *Allow for coordination plans at designated speeds*
5) *Permit pedestrian movements*
6) *Permit cross-street movements*

However, the improperly operated traffic control signals result in the following short falls.

1) *Increase of vehicle volumes along the road.*
2) *Signals not functioning as safety devices; crashes will often occur.*
3) *Delays will increase.*
4) *Increase of operations and maintenance costs.*

To implement this, the Computer Based Master Control System (CBMCS) including interconnections and optimazation were used in the design.

In this research, the CBMCS was selected since it incorporated the other two methods to deliver the most cost effective solution for the operating environment.

3.2 Controller Types

According to the research done by A. P. Davol (2001), traffic control types were divided into two parts which are:

(i) Control logic (Pre-timed, Actuated and Adaptive), and
(ii) Control Scope (Isolated intersection, Arterial Coordination and Networked Control).

Fig. 1: Presents the matrix for traffic control types as per A. P. Davol

		Control Scope (infrastructure)		
		Isolated Intersection	Arterial Coordination	Network Control
Control Logic (ICT Strategies')	Pre-timed	◙	◙	◙
	Actuated	◙	◙	◙
	Adaptive	◙	◙	◙

Figure 1. Types of signal control

Key:

◙ Point of coincidence between control scope infrastructure and control logic strategy.

[1] ◙ The part that is being pursued

3.3 Signal Timing for independent colour indication

Three different signal color indications which need different timings are Red, Yellow and Green.

1. Green interval determination

By implementing the necessary arithmetic and logic computations using several variables like cycle (cycle length), phase (signal phase), time intervals (fixed and variable), time lapse/offset, clearance intervals, peak-hour factor shown in (1) and saturation flow rate. 15 minutes within peak hour is used to determine the variability of demand.

$$PHF = \frac{\text{volume during peak hour}}{\text{4 x volume during peak 15min within peak hour}} \qquad (1)$$

In an ideal situation, the saturation flow (S_0), is taken as 1900 veh/hr of the green time per lane. In the real practical situation, the ideal data has to be adjusted in order to obtain the practical saturation flow for the lane group being considered.

2. Yellow interval determination

The required yellow interval is the time period that guarantees an approaching vehicle either to stop safely or proceed through the intersection without speeding. A bad choice of yellow interval may lead to the creation of a dilemma zone. For the dilemma zone to be eliminated, the distance X_0 should be equal to the distance X_c. Let ζ_{min} be the yellow interval (sec) and let the distance traveled during the change interval without accelerating be the product of u_0 and (ζ_{min}), with u_0 = speed limit on approach (m/s) the vehicle just clears the intersection, then

$$X_c = U_o\tau_{min} - (W + L_V) \qquad (2)$$

Where X_c is the distance within which a vehicle traveling at the speed limit (u_0) during the yellow interval ζ_{min} cannot stop before encroaching on the intersection, W is the width of the intersection in meters and Lv is the average length of a vehicle in meters. Vehicles within this distance at the start of the yellow interval will therefore have to go through the intersection.

For vehicles to be able to stop, however, the situation is governed by (3).

$$X_0 = u_0\delta + \frac{u_0^2}{2a} \qquad (3)$$

Where X_0 is the minimum distance from the intersection for which a vehicle traveling at the speed limit u_0 during the clearance interval Y_0 cannot go through the intersection without accelerating. Any vehicle at this distance or at a distance greater than this has to stop. Also, δ = perception – reaction time (sec) and a = constant rate of breaking deceleration (m/s^2).

For the dilemma zone to be eliminated X_0 must be equal to X_c. Accordingly,

$$U_o\tau_{min} - (W + L_V) = \delta + \frac{U_o^2}{2a} \qquad (4)$$

And

$$\tau_{min} = \delta + \frac{(W + L_V)}{U_o} + \frac{U_o}{2a} \qquad (5)$$

Safety considerations normally preclude yellow interval of less than 3sec to encourage driver's respect for the yellow interval. It is usually not made longer that 5 sec. When longer yellow intervals are required, an all-red phase can be inserted to follow the yellow indication. The change interval, yellow plus all-red, must be at least the value computed from (5).

3. Determination of Cycle length for the intersection

Several design methods have been developed to determine the optimum cycle length. Two of which are the Webster method and the Highway Capacity method. In this research the Webster method is used.

Optimum Cycle Length. Webster (1958), has shown that, for a wide range of practical conditions, minimum intersection delay is obtained when the optimum cycle length is obtained when (6).

$$C_0 = \frac{1.5L + 5}{1 - \sum_{i=1}^{\phi} Y_i} \qquad (6)$$

Where; C_0 = optimum cycle length (sec), L = total lost time per cycle (sec), Ø = number of phases, Y_i = maximum value of the ratio of approach flows to saturation flows for all lane groups using phase *i*, i.e. q_{ij}/S_j and q_{ij} = flow on lane group having the right of way during phase *i.*

Total Lost Time: Initially, some time is lost before the vehicle start moving, and then the rate of discharge increases to a maximum. If there are sufficient vehicles in the queue to use the available green time, the maximum rate of discharge will be sustained until the yellow phase occurs. The rate of discharge will then fall to zero when the yellow signal changes to red. Dividing the number of vehicles that go through the intersection by the saturation flow will give the effective green time, which is less than the sum of the green and yellow times. This difference is considered lost time, since it is not used by any other phase for the discharge of vehicles; it can be expressed by (7).

$$\ell_i = G_{ai} + \tau_i - G_{ei} \qquad (7)$$

Where; ℓ_i = lost time for phase *i,* G_{ai} = actual green time for phase i (not including yellow time), τ_i = yellow time for phase *I* and G_{ei} = effective green time for phase *I*. Then (8) gives L.

$$L = \sum_{i=1}^{\phi} \ell_i + R \qquad (8)$$

Where, R is the total all-red time during the cycle.

Allocation of Green Times: In general, the total effective green time available per cycle is given by (9)

$$G_{te} = C - L = C - \left(\sum_{i=1}^{\phi} \ell_i + R \right) \qquad (9)$$

where C = actual cycle length used which is the rounded off C_0 to the nearest 5 sec and G_{te} = total effective green time per cycle

To obtain minimum overall delay, the total effective green time G_{ei} *given by (10)* should be distributed among the different phases in proportion to their Y values to obtain the effective green time for each phase.

$$G_{ei} = \frac{Y_i}{Y_1 + Y_2 + ... + Y_\phi} G_{te} \qquad (10)$$

And the actual green time for each phase is given by (11)-(14).

$$G_{a1} = G_{ei} + \ell_1 - \tau_1 \qquad (11)$$

$$G_{a2} = G_{ei} + \ell_2 - \tau_2 \quad (12)$$

$$G_{ai} = G_{ei} + \ell_i - \tau_i \quad (13)$$

$$G_{a\phi} = G_{e\phi} + \ell_\phi - \tau_\phi \quad (14)$$

3.4 Signal timing for adaptive system

By examining the possibility of traffic flow coordination in urban areas, where road junctions are networked. The signals should be timed so that when a queue of vehicles is released by receiving a right of way at the first intersection I(n), these vehicles will also have the right of way at the intersection I(1), I(2) and I(n-1) to I(n). This coordination will reduce the delay experienced by vehicles on the arterial. To obtain such coordination, all junctions in the network must have the same cycle length or multiple cycle length, in such a way that some junctions in the network may have cycle length equal to half or twice the common cycle length. It is usual for the common cycle length to be set, with an offset that is suitable for the main street. Traffic conditions at a given intersection are used to determine the appropriate phase of green, red and yellow periods for that intersection. The methods used to achieve the required coordination are the Simultaneous, Alternate and Progressive system. The speed of progression is important in determining the cycle length for each of these methods.

The speed of progression is the speed at which a platoon of vehicles released at I(n) intersection will proceed along the arterial intersection I(n+1). It is usually taken as the mean operating speed of vehicles on the adaptive network for the specific time of the day being considered. This speed is represented by the ratio of the distance between the traffic signals and the corresponding travel time.

Simultaneous System: All signals along a given adaptive network shall have the same cycle length and have the same green phase showing at the same time. When given the right of way, all vehicles shall move along the street in the greed direction of the adaptive network. The first vehicle shall travel from start and stop at the nearest signalize intersection when the right of way is given to the side street. An approximate mathematical relationship for this system is given by (15)

$$u = \frac{X}{1.47C} \quad (15)$$

where; X = average spacing for the signals (km),

u = progression speed (km/hr), and C = cycle length (hr).

Alternate system: Intersection on the arterial are formed into groups of one or more adjacent junctions. The signals are then set such that successive groups of signals are given the right of way alternately. This system is known as the single-alternate with those immediately adjacent to it. It is known as double-alternate when the groups are made up of two adjacent signals, and so on. The speed of progression in an alternate system is given by (16).

$$u = \frac{nX}{1.47C} \quad (16)$$

Where; n = 2, for the simple-alternate system, n = 4, for the double-alternate system, and n = 6, for the triple-alternate system.

Progressive system: The progressive system provides for a continuous flow of traffic through all junctions under the system when traffic moves at the speed of progression. The same cycle length is used for all junctions, but the green indication for each succeeding intersection is offset by a given time period from that of the preceding intersection, depending on the distance from the preceding intersection and the speed of progression for that section of the street. When the offset and cycle length are fixed (pre-timed control), the system is known as limited or simple progression system. When the offset and cycle length are changing to meet the demand of fluctuating traffic at different times of the day (adaptive control), it is known as the flexible progressive system [5].

3.5 Simulations

Junctions along all major roads such as Bagamoyo Road, Morogoro Road, Nyerere Road and Kilwa Road in Dar es Salaam city were simulated for analysed.

For Bagamoyo Road, the selected junctions were Maktaba, Nyumba ya Sanaa, Red Cross, and others up to Mwenge junction. The separating distances between junctions ranges between 100m to 1000m. Previous results shows that the separating distance of not more than 150m could allow arterial co-ordination and intelligent Arterial co-ordination could be extended up to 250m for two junctions (Hamisi et al, 2009).

Data collection and analysis of normal and peak hour traffic volumes was performed. Using the data presented in Table I, calculations of traffic control parameters (signal timing) for each intersection in the system were performed to obtain the control algorithm for intersection coordination.

Experiments started by identification of Traffic Volumes along Bagamoyo Road from Maktaba to Morroco as per Fig. 2. The phasing scheme and then an arbitrary phase assignment were selected. Table II presents the phasing scheme for one particular intersection.

TABLE I. EQUIVALENT MORNING HOURLY TRAFFIC FLOW FOR 10 JUNCTIONS

JUNCTION	CODE	PHASE A		PHASE B		PHASE C		PHASE D		TIME
		LT+TH	RT	LT+TH	RT	LT+TH	RT	LT+TH	RT	
MOROCO	10	1150	300	1000	250	900	200	600	500	AM
		500	250	1200				800	100	PM
NAMANGA	9	1300	500	1200				800	100	AM
		1300	500	1250				500	100	PM
KANISANI	8	450	50	1800				150	300	AM
		1500	250	1300				150	300	PM
UBALOZI	7	600	100	1850	50	300	800	750	50	AM
		1200	150	1150	50	100	400	150	50	PM
POLICE SA	6	700		2200	700	350	250			AM
		1500		2200	700	350	250			PM
PALM BEA	5	400	50	1500				100	500	AM
		1200	50	1300				100	500	PM
HINDU T	4	400	50	1500		100	100	100	500	AM
		1200	50	1300		100	100	100	500	PM
RED CROS	3	350	150	1700	100			200	100	AM
		1500	300	1200	100			200	50	PM
N Y SANAA	2	1000	300	1600				500	100	AM
		1300	250	1300				500	500	PM
MAKTABA	1	800	500	1100				500	200	AM
		900	500	1200				600	600	PM
MEA		715								
		1210								
STD D										

By using data presented in Tables I-III, the equivalent traffic flow with offset time between junctions for the 10 junctions using the phasing scheme was presented as per Table IV. For junctions along Bagamoyo Road which is 18 m wide, the maximum driving speed allowed in Dar es Salaam is 50km/hr (equivalent to 13.89m/s) and the average length of a vehicle is assumed to be 6m. The American Association of State Highway and Transportation Officials (AASHTO) recommend a deceleration rate of 3.4m/sec^2. Taking the driver reaction time to be 1.0 seconds, the minimum yellow time at the end of each green phase is obtained by substituting the values into (5). Substituting *δ, W, L, U_0 and α* in (5), τ_{min} is 5.92sec. Rounding the value to the nearest multiple of five we get a minimum yellow time of 6sec is needed.

TABLE II. DATA ENTRY FOR BAGAMOYO ROAD

	intersectID	phaseID	phaseName	greenTime	yellowTime	redTime	signalID	priority
1	Bamaga	PhaseA	Mwenge	55	5	2	1A	1
2	Bamaga	PhaseC	Sayansi	29	5	2	1C	3
3	Bamaga	PhaseD	Sinza	35	5	2	1D	2
4	Maktaba	PhaseA	N Y Sanaa	33	5	2	1A	1
5	Maktaba	PhaseB	Posta	33	5	2	1B	2
6	Maktaba	PhaseC	Bibi Titi	53	5	2	1C	3
7	Mbuyuni	PhaseA	Namanga	30	5	2	1A	1
8	Mbuyuni	PhaseB	Masaki	24	5	2	1B	2
9	Mbuyuni	PhaseC	Ubalozi	65	5	2	1C	3
10	Moroco	PhaseA	Sayansi	33	5	2	1A	1
11	Moroco	PhaseB	Sayansi	18	5	2	1B	2
12	Moroco	PhaseC	Namanga	38	5	2	1C	3
13	Moroco	PhaseD	Magomeni	23	5	2	1D	4
14	Mwenge	PhaseA	Lugalo	26	5	2	1A	1
15	Mwenge	PhaseB	Ubungo	12	5	2	1B	2
16	Mwenge	PhaseC	Bamaga	46	5	2	1C	3
17	Mwenge	PhaseD	Coca Cola	28	5	2	1D	4
18	N Y Sanaa	PhaseA	Red Cross	29	5	2	1A	1
19	N Y Sanaa	PhaseB	Movenpick	36	5	2	1B	2
20	N Y Sanaa	PhaseC	Maktaba	54	5	2	1C	3

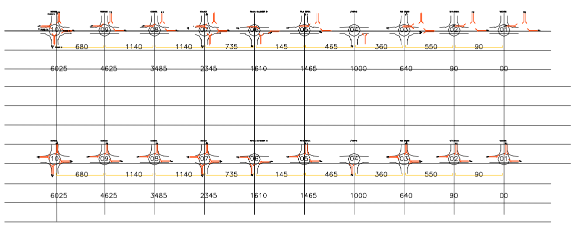

Figure 2. AM and PM Traffic Volumes along Bagamoyo Road from Maktaba to Morroco Junctions

3.6 Determination of Minimum Yellow Interval

Consideration has also been made for an all red phase. Since there are three to four phases per intersection, the total lost time per cycle per intersection is 2sec per red signal. For 4 Cycles, the total all red loss time is 8 sec, assuming that the effective green time is the same then the actual green time, will be given by (17).

$$L = \sum (Yellow + \text{Red}) \quad (17)$$

Determination of Optimum Cycle Length

Using Webster equation described in (7), the optimum cycle lengths for 10 junctions were calculated.

CYCLE LENGTH DETERMINATION USING WEBSTER'S APPROACH

INTERSECTION CODE 01 - MAKTABA

	Phase A		Phase B		Phase C		Phase D	
Signal group	RT	TH+LT	RT	TH+LT	RT	TH+LT	RT	TH+LT
q_{ij}	500	800	0	1100	0	0	200	500
S_j	1615	3700	1615	3700	1615	3700	1615	3700
q_{ij}/S_j	0.03	0.216	0.04	0.297	0	0	0.124	0.135
Y_i	0.310		0.297		0.00		0.135	

Total cycle length : $\sum Y = 0.742$ (17)

Tmin= δ +(((W+L) / Uo))+ (Uo / (2*(a + G g)))= 5.92 sec (18)

R = 2 sec

L = 4(Tmin+R)= 31.69 (19)

$$C_0 = \frac{1.5L + 5}{1 - \sum_{i=1}^{\phi} Y_i} = 132 \text{ sec} \quad (20)$$

$Co - L =$ 132-32=100 sec (21)

Actual green time per phase i(th) is

	Phase A		Phase B		Phase C		Phase D	
Signal group	RT	TH+LT	RT	TH+LT	RT	TH+LT	RT	TH+LT
	48sec		40sec				18sec	

The effective green time was found to be 106sec which is the total green time for all phases. Subsequently, optimum cycle length for each intersection was computed, and obtained by repetition of iterations as presented in table II. Since cycle lengths are usually multiples of 5 or 10, the calculated value was rounded to multiples of 5 like 110sec, 115sec, and 120sec

3.7 Determination of Offset

Using the progressive system, the average distance between junctions and the average speed of progression are needed. The distance between each intersection and the offset that adaptive networked traffic for the first vehicle shall move from the first intersection to the next intersection are presented in Table IV, and vehicles are set to the average speed of progression of about 50km/hr ($\approx$13.89 m/s).

$$\text{Ideal speed} = \text{Ideal distance (m)}/\text{Ideal time (sec)} \qquad (22)$$

3.8 Algorithm for Coordinating the Junctions

Using calculated values of effective green time and offset, an algorithm for coordinating the intersection in mode three of Fig.1 was developed as presented in Fig.3, which also led to the development of the model for controlling and coordination the traffic flow for more one intersection and corridor presented in Fig.4.

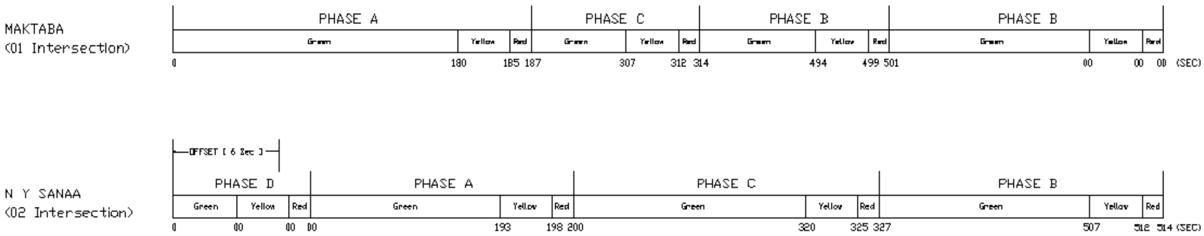

Figure 3. Green Phase timing algorithm for two adjascent intesection in aadaptive networked traffic conttrol

TABLE III. OFFSET TIME BETWEEN JUNCTIONS

S/N	Junctions	Ideal Distance (m)	Time (sec)
1	Maktaba & Nyumba ya Sanaa	90	6
2	Nyumba ya Sanaa & Red Cross	550	40
3	Red Cross & H Tample	350	26
4	H Tample & Palm Beach	465	33
5	Palm Beach & Salender Police	145	10
6	Salender Police & Ubalozi	735	53
7	Ubalozi & Kanisani	1140	82
8	Kanisani & Namanga	450	32
9	Namanga & Morocco	680	49

4.0 DISCUSSION

4.1 Client-Server Architecture

As presented in Fig. 4, we found the best method is to use the client–server model of computing which is a distributed application structure that partitions tasks or workloads between the providers of a resource/service, called Servers, and service requesters, called Clients. By visual basic program, Many Clients and one Server were programmed to communicate over a modeled computer network. A server was made to run visual basic program and shared its resources with clients. A client did not share its resources, but was made to request a Server's content/services and functions. Clients were made to initiate communication sessions with servers which continuously kept on waiting for the incoming requests.

4.2 Distributed Computing

The networked Client–Server architecture enabled distributed computing of independent computers connected to each other through the Intelligent Traffic Control System (ITCS) network. This created flexibilities in replacement, repair, upgrade, and server relocation. Clients remained either unaware or unaffected by Server changes. All data were stored on the Server, which generally had greater security controls than clients. Server was made to control access and resources, in such a way that only Clients with appropriate permissions accessed and exchanged data. Data storage was centralized, which made data updates easy. Issues of security, and interface were addressed as presented in Fig:4.

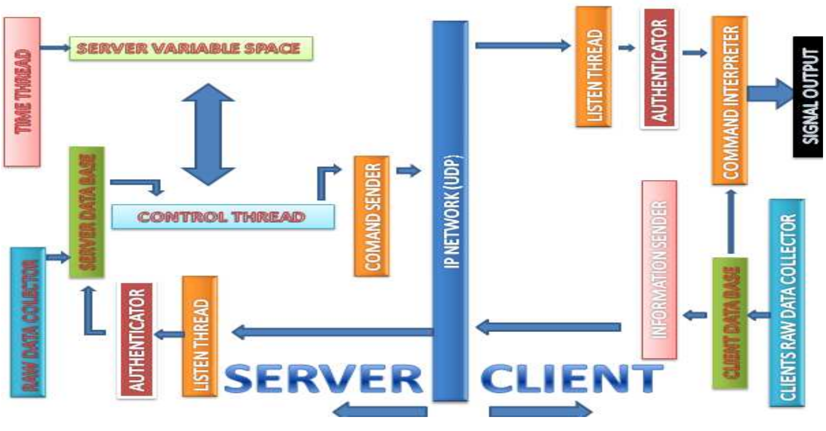

Figure 4. Client Server Architect

4.3 System constrains

With simulations of ten junctions at once, each Client generated about 12kb/sec and in total, the Clients Server Network generated about 120kb/sec at the Server Node.

By taking into account that there was data which was lost in transmission process. Then ITCS network occupied less than 1:100 or 1% of 1000Mbps (1Gbps) ITCS network total capacity when User Datagram Protocol (UDP) was used. By adding more Clients, the bandwidths across the network were increased in the same proportions.

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TABLE IV. INTERSECTION INFORMATION TO THE NETWORK

	intersectName	intersectID	ipAddress	cycleLength	intersectType	intersectOffset
1	Bagamoyo - Shekilango	Bamaga	192.168.1.11	140	1	94
2	Bibi Titi - Azikiwe	Maktaba	192.168.1.1	140	1	0
3	A H Mwinyi - Haile Selassie	Mbuyuni	192.168.1.7	140	1	113
4	A H Mwinyi - Kawawa	Moroco	192.168.1.9	140	1	69
5	Bagamoyo - Sam Nujoma	Mwenge	192.168.1.12	140	1	94
6	A H Mwinyi - Ohio	N Y Sanaa	192.168.1.2	140	1	6
7	A H Mwinyi - Old Bagamoyo Road	Namanga	192.168.1.8	140	1	11
8	A H Mwinyi - Ocean Road	Palm Beach	192.168.1.4	140	1	105
9	A H Mwinyi - Ufukoni	Red Cross	192.168.1.3	140	1	46
10	A H Mwinyi - Ocean Road	Salender Bridge	192.168.1.5	140	1	116
11	Bagamoyo Road - Rose Garden	Sayansi	192.168.1.10	140	1	116
12	A H Mwinyi - Kinondoni	Ubalozi	192.168.1.6	140	1	29

TABLE V. SIGNAL TIMING FOR PLATOON FLOW FROM MAKTABA INTERSECTION TO MOROCO INTERSECTION

Intersection	Phase A	Phase B	Phase C	Phase D	Total	Ofset Time	Platoon Green Start Start	Platoon Red Signal Start
							Green	Red
Maktaba	22	33	28	0	83		0	180
						6		
N Y Sanaa	26	45	30	0	101		28	186
						40		
Red Cross	30	46	6	0	82		68	226
						26		
H Tample	21	70	0	9	100		94	252
						33		
Palm Beach	21	70	9	0	100		127	285
						10		
Police Salender	36	50	14	0	100		137	295
						53		
Ubalozi	27	15	29	17	88		190	348
						82		
Kanisani	21	46	9	0	76		272	430
						32		
Namanga	21	38	19	0	78		304	462
						49		
Moroco	21	38	29	29	117		353	511

4.4 Visual basic

During development, Visual Basic which has multithreading capabilities was used. Tasks involved were established in streams ready for execution. Lengthy tasks were divided into different segments. In so doing, the processors were optimized, thus avoiding idle time. On both Server and Client application, threads were used to provide concurrence for different processes.

4.5 Event Timers

The crucial event was the use timer to synchronize ITCS coordination across several road junctions. On the server, events were realised using timer. Visual Studio.NET and the .NET Framework.

Out of existing three timer controls (which are (i) the server-based timer (ii) the standard Windows-based timer and (iii) the thread timer), the server-based timer was designed for use with worker threads in a multi-threaded environment. Because they use a different architecture, server-based timers was more accurate than Windows timers. Server timers moved among threads to handle the raised events. Because the program design of ITCS was based on a Multi-threaded architecture, Server-based timer was used to manage the program flow and control time for junctions.

4.6 ITCS database for a single intersection

Intersection details and timing information was stored on a relational database on the Server as per Fig. 5. From sets of tables formulated from data collected from road junctions, formulations of relational database were carried. Fig: 4&5 presents ITCS data base information for one intersection which was formulated by using the Structured Query Language (SQL). SQL statements were used for interactive queries to insert and/or retrieve information from a relational database.

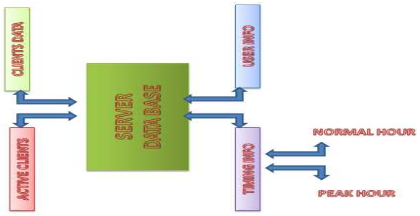

Figure 5. ITCS Database architect for one intersection

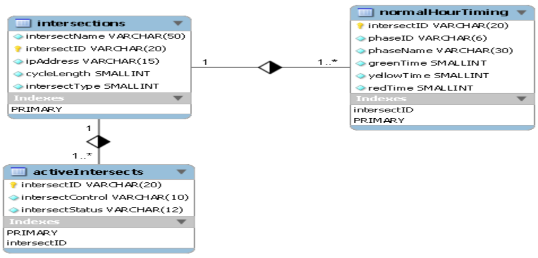

Figure 6. ITCS Database content for one intersection

The created ITCS database, made it relatively easy to create, access, and add new data category without requiring modifications of previous data.

5.0 ACKNOWLEDGMENT

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4.0 CONCLUSION

In this paper, a complete cycle for development of ICT as a tool for development of Traffic Control Systems by ITCS network has been presented. The design and methodology used for implementation was multithread client server programming for developing the ITCS. The paper proposes the applications of the system in the local (Dar es Salaam City) environment. Raw data which were used at first instance, could be used to initiate the system and keep the system running. With real time data acquisition, the data base can be updated and run ITCS accordingly. By using Webster Equation, data were computed and coded in order to build an algorithm for Socket Programming. Such algorithm, led to the development of the ITCS, which is part of ITS. It was found that the application of multithread client server networking has potentials to alleviate the present traffic signal control problems mostly facing the cities in developing countries. The practical implications of ITCS network could be upon improvement of usage of computer applications in solving heavy traffic problems we are facing. Furthermore, the complexity of adaptive networked controller which was said to be complex in 2000 (Davol, A. (2001) has now been realized by improving features of pre-timed and arterial logic.

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