Analysing Commuters’ Attitudes towards the Proposed Bus Rapid Transit System in Dar es Salaam, Tanzania: Using Stated Choice and Spatial Analysis.

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Analysing Commuters’ Attitudes towards the Proposed Bus Rapid Transit System in Dar es Salaam, Tanzania: Using Stated Choice and Spatial Analysis

By

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Abstract

The study examines the perceptions and preferences of commuters towards the proposed DART System and compares the preferences of commuters based on their socio-economic and spatial difference characteristics. This is carried out to identify how commuters perceive and value the proposed DART system and its attributes in view of providing affordable, quality and accessible service. A questionnaire-based Survey was administered to 684 respondents using a stated-preference approach to look at how the DART potential users perceive and prefer the DART attributes.

The commuters’ preferences are analysed and discussed with respect to the proposed DART attributes: travel time, travel fare and comfort and with respect to their socio-economic and spatial location differences. A choice model using binary-logit is employed to estimate the DART attribute parameters and in deriving the Utility models. The results found for different analyses in this study are compared with those reported in literature.

The study also uses a scenario-based approach to assess the impact that the DART system will have on the preferences of commuters by comparing a case “Without DART” representing the existing public transport (Daladala) as the base scenario and the “DART” as the second scenario. A GIS-based approach is attempted to bring out the underlying preferences of commuters in accessing the proposed DART service based on their regular trips to the Central Business District (CBD). Given the Utility models, the preferences of commuters are modelled spatially using the GIS spatial analysis techniques. In a GIS environment, Commuter preferences are mathematically modelled which computes a utility value for each spatial unit. The results of the GIS model are displayed for visual examination of the preference differences of the commuters by their spatial locations.

The results indicated that nearly 70% of the total population would be served within 15 minutes walking time to the proposed DART Service at DART stops and 65% of the area is covered within 15 minutes walking time. The stated choice model results indicate that generally travel time, travel fare and Comfort have a statistically significant effect on DART choice. Comfort is the most important attribute and travel fare is the least important based on commuters’ valuation. From the spatial analysis results, generally the DART was found to be more preferred to the existing public transport “without DART” (Daladala). Commuters from the peripheral zones of the city have considerably higher preferences for the DART compared to existing public transport (without DART). Results have shown that 68% of the Traffic Analysis Zones (TAZ) also used as residential zones in this study increased their preferences for the proposed DART service, 16% had no effect and the remaining 16 % have decreased their preferences in reference to the base scenario (without DART).

Keywords: BRT; DART; Commuters; Stated preference; Stated choice; Modeling; Spatial analysis
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1. Introduction

1.1. General Introduction

Transport is the back bone of urban life. It is one of the factors which determines the form and socio-economic development of a city. Mobility and accessibility provided by the transport system have been playing a major role in shaping countries, influencing the location of social and economic activity, the form and size of cities, and the style and pace of life by facilitating trade, permitting access to people and resources, and enabling greater economies of scale, worldwide and throughout history (Zuidgeest, 2005)

However, increased urbanization and population growth, urban expansion, dispersal of amenity and activity have increased the demand for and dependence on motorized transportation. Consequently, urban transportation problems like congestion, accidents, environmental degradation and urban sprawl have increased. Sustainable transport development plans are thus replacing the routine approach of building more roads to alleviate congestion with an integrated transport system which is affordable, space and resource-efficient, and minimizes environmental impacts and transport nuisances (Menckhoff, 2002). As a consequence, encouraging and improving public transport system in developing and the developed world has got wider attention and has become a central issue in transport planning.

Public transport is a collection of modes of transport which are available to the public irrespective of ownership (White, 2002). It includes road-based modes like conventional buses, Para-transit vehicles, human and animal powered vehicles, cycles and walking; rail-based models like heavy rail system, light rail transit, street tramway; and bus rapid transit systems (Fulton, 2002). Among these modes, the bus rapid transit is praised for its high quality customer-oriented transit service (Wright, 2002a).

Some people believe public transport is the “panacea” for some urban transport problems and its importance has been widely acknowledged. It helps to overcome some of the social and environmental impacts of transport system which includes mobility problem for the disadvantaged groups (e.g. poor, handicapped and elderly), congestion, accident, environmental impact, land consumption, urban sprawl and energy consumptions. It also provides mobility for those who cannot drive their own cars; helps in creating and maintaining liveable communities; relieves highway congestion; assures long-term sustainability in terms of resource consumption and the environment (Black, 1995).

1.2. Background and Justification of the Research

Dar es Salaam, a city with a population of almost 2.5 million according to Population and housing census (2002) used to be the official capital of Tanzania. Although Dodoma became the official capital, Dar es Salaam still is the largest and most important commercial and administrative city in Tanzania. This importance is reflected in the ongoing population growth of this city of well over 4% per annum, while the total population growth in Tanzania is limited to only 3%. So Dar es Salaam still is one of the fastest growing cities in the country (Population and housing census[PHC], 2002).
The city is characterized by a high proportion of informal development and poverty where nearly 70% of its population lives in informal settlements meaning that most people are low income earners (World Bank, 2002).

Since most people in the city are relatively poor and cannot afford a private car, public transport is one of the most common transportation modes that can be accessed by the urban population where around 75% of trips in Dar es Salaam are made by walking and public transport (ITDP, 2003). Like any other rapid growing city in the developing world, Dar es Salaam has not escaped from the impacts of poor public transport services, improvements in Dar es Salaam's public transit network will improve mobility for residents who currently rely on inefficient and unpredictable minibus and microbus services. It is in this respect the government has decided to implement a Bus Rapid Transit (BRT) System, the Dar es Salaam Rapid Transit (DART) according to (ITDP, 2005). The proposed DART System is defined by a combination of these components together: main trunk, feeders, bus stops and operational characteristics. A BRT system is praised as public transport’s response with an attempt to provide a car competitive quality service (Wright, 2002a).

According to Wright (Wright, 2002a), Bus Rapid Transit (BRT) refers to high quality customer-oriented transit that delivers fast, comfortable and cost-effective urban mobility. BRT can provide high-quality, metro-like transit service at a fraction of the cost of other options, a cost that most cities, even developing cities can afford (Wright, 2002a). A BRT is a new mass rapid transit system and its origin can be traced in Latin America, where it was introduced in the 1970s to accommodate the large amount of commuters in growing cities with limited financial resources (Wright, 2002a). Mass Rapid Transit (MRT) refers to those modes of urban public transport which have their own specific fixed track, or have exclusive use of the urban street network over most of their alignment such as rail based metros, bus rapid transits (Menchkoff, 2002). Latin America BRT system developers astutely observed that the ultimate objective was to swiftly, efficiently and cost-effectively move people rather than cars (Wright, 2002a). Today, the BRT concept is becoming increasingly utilized by cities looking for cost-effective transit solutions. A BRT has a couple of main characteristics that distinguishes it from a ‘normal’ bus line and include: Segregated bus ways, Rapid boarding and alighting, clean, secure and comfortable stations and terminals, efficient pre-board fare collection, effective licensing and regulatory regimes for bus operators, clear and prominent signage and real-time information displays, Transit prioritization at intersections, modal integration at stations and terminals (Wright, 2002a).

The BRT in cities such as Bogotá and Curitiba in Latin America have provided a world class mass transit service accessible for all groups of people especially the poor. Accessibility of the BRT to the urban poor has shown a great achievement of the main objective of public transport which is to facilitate participation of less mobile people (disadvantaged group) in economic activities and improve mobility of all groups (Fjellstrom, 2002).

1.2.1. Justification of the Research

Bus Rapid Transit (BRT) has emerged as an economically advantaged mass rapid transit system with significant potential in developing cities. Many cities recently announced plans for introducing BRT corridors and among them include Dar es Salaam city, Tanzania (ITDP, 2003). Although the development of a BRT system is viewed by many as the preferred solution for urban mobility problems, its success can not be taken for granted. There are many different aspects that need to be taken care of, before a BRT can operate. One of the most important aspects are its accessibility by all
the socio-economic groups of the urban community, its actual performance and potential impacts, all which have hardly been researched especially in low income countries with weak economies among which Tanzania is one. Therefore, it is in this respect the researcher intends to carry out a BRT accessibility study with a central focus on analysis of attitudes and preferences of the potential users of the proposed BRT system in relation to the system’s proposed characteristics in Dar es Salaam, given the limited resources and time constraints of this research.

1.2.2. Research Problem

The BRT in cities such as Bogotá and Curitiba in Latin America have provided a world class mass transit service accessible to the urban community especially the poor (Fjellstrom, 2002). Experience drawn from BRT in Curitiba, Bogotá, Sao Paulo and Quito show that BRT systems in developing cities can provide an excellent service popular with high and low income users, and also be profitable at a low fare in comparison with other mass rapid transits (Wright, 2002b). BRT can play an important role in alleviating poverty as it is the low income people who mostly depend upon public transit for access to jobs and services (Fjellstrom, 2002). Concentrating on the transport modes that meet the high mobility need of all the socio-economic groups of the urban community calls for the provision of affordable forms of public transport, thus public transport should not be viewed as only for the poor, as wealthy European and Asian cities show (Wright, 2002b). It is in this view, Dar es Salaam government has decided to implement a BRT, the Dar Rapid Transit (DART) that will provide improved transit possibilities (ITDP, 2005).

Although the BRT System in Bogotá and other Latin American cities have shown great success with undeniable improved quality service, this may not be taken for granted. Based on the 2002 census statistics and World Bank Assessment Report, 2002 where 70% of its population is low income people characterized by poverty, Dar es Salaam people may have different socio-economic and behavioral characteristics from people in those cities. Fjellstrom (2002) argues that in some cities, people pay up to 30% of their income on transport and also typically live in lower rent areas located in the city outskirts and in some cases spend two to four hours commuting each day, how true is this statement in the case of Dar es Salaam city. Importantly, a BRT needs to cover its operational cost that is pretty expensive which may be transferred to the customers in terms of price and service quality and this may affect willingness of the people to pay for and use the BRT. Looking at the BRT system this way, a research has to be conducted to investigate commuters’ travel attitudes and preferences in relation to the proposed Dar Rapid Transit (DART) system characteristics in terms of proximity, travel cost and service quality for access benefits of all groups of the urban community.

1.3. Research Objectives and Questions

1.3.1. Main Research Objective

The main objective of the research is to investigate whether the proposed DART system will provide quality, accessible and affordable mass transportation service to all groups of people by analysing and making comparison between the system’s proposed characteristics and commuters’ stated preferences.
1.3.2. **Specific Research Objectives**

1. To identify the proposed DART system characteristics and its spatial coverage.
2. To examine commuters’ attitudes and preferences to use the proposed DART Service.
3. To assess the proposed DART System characteristics based on commuters’ stated preferences.

1.3.3. **Research Questions**

Table 1-1: Research Objectives and Research Questions

<table>
<thead>
<tr>
<th>No.</th>
<th>Specific Research Objectives</th>
<th>Research Questions</th>
</tr>
</thead>
</table>
| 1   | To identify the proposed DART System Characteristics and its spatial coverage.              | • What are the proposed characteristics of the DART system?  
                                              |                                                                                                   | • How is the proposed DART service spatially distributed?  
                                              |                                                                                                   | • Is the proposed DART system equally accessible by all economic groups? |
| 2   | To examine commuters’ attitudes and preferences to use the proposed DART service            | • What are the variables that determine the choice of a particular public transport mode?  
                                              |                                                                                                   | • What will be the likelihood for commuters to use the proposed DART service?  
                                              |                                                                                                   | • How do different economic groups of commuters value the proposed DART characteristics based on their preferences? |
| 3   | To assess the proposed DART System characteristics based on commuters’ stated preferences   | • How is the proposed DART system spatially distributed with inputs from commuters’ stated preferences?  
                                              |                                                                                                   | • How effective is the proposed DART system & its characteristics in relation to commuters’ preferences?  
                                              |                                                                                                   | • How are the commuters’ preferences related to the proposed DART System characteristics? |
1.4. Conceptual framework

![Conceptual framework diagram]

Structuring the ideas of this research as shown in figure 1 above is built based on the relationship between transport demand and transport supply concepts which can be derived largely from economic theory. This is explained by four aspects of economic theory for transport problems: consumer travel behaviour, demand, supply and equilibrium (Zuidgeest and Maarseveen, 2007a). The basic premise of consumer behaviour theory is that an individual will select a bundle of goods over all affordable bundles if it yields the greatest utility. The demand for a good therefore depends on its price, characteristics and the characteristics of the consumer. In case of transport, the good being demanded is a certain transport service and the price consists of all perceived costs of the traveller, not only the monetary costs of the trip but also the time spent travelling and quality characteristics of the trip. Demand for travel is a derived demand as it is generated by the desire to join activities and due to the derived nature of it, transport demand cannot be analysed without considering the socio-economic characteristics of an area (Zuidgeest, 2005). The demand for travel calls for the supply of transport service which is a function of price of the good, including the price of input factors and the technology used to produce the good. It is assumed that at a certain point in the market, there will be equilibrium.
where transport demand will equal transport supply. Unlike in private sector where the objective is to maximise private benefits, social facilities and services are supplied with the aim of providing social welfare. These facilities and services should be accessible by the target population to achieve the intended objective.

Based on the above theoretical concepts and as shown in the conceptual framework figure 1 above, the demand for high-quality transit service, called for the supply of the proposed DART system. This is a result of travel demand generated by people who desire to participate in activities located in space and time, thus the proposed DART system should be accessible to provide services to the generated demand. The accessibility of the proposed DART system will depend on the spatial locations of activities, socio-economic and behavioural characteristics of the commuters and their public transport preferences. Based on this, therefore, the proposed DART should be able to provide services accessible for all socio-economic groups to satisfy their travel needs and preferences in order to achieve its intended objective and sustainability.

Access to the proposed DART system can be measured in terms of travel time, travel cost and quality of service to be offered. In the research, accessibility to the proposed DART system service will be assessed by analysing commuters’ stated preferences on public transport and the results will be compared with the DART proposed characteristics and based on the findings, conclusion on the system effectiveness will be drawn. If found that the proposed DART characteristics meets commuters’ stated preferences, then the system is likely to have a positive effect, meaning that the proposed DART system is likely to be attractive for people to use. Otherwise, the system is likely to be less effective if the findings show that the proposed system characteristics/attributes do not meet commuters’ preferences. Thus, in such case recommendations on improvement of the system characteristics based on commuters’ stated-preferences will be proposed. The methodology and approach of the research is elaborated in the research design.

1.5. Research Design

The figure below shows the procedures that were followed in carrying out the research. The research problem was identified through literature review and investigation of the real world problem. Based on the research problem, appropriate research objectives were defined and questions were formulated to operationalise them in order to obtain answers to the problem. Next, key concepts were conceptualised and operationalised based on literature review.

Also based on literature the required data was identified and was collected during field work. The data was prepared and assumptions were taken to make it suitable for analysis. Finally, data analysis at different levels was carried out where statistical and spatial analysis were done to investigate whether the proposed DART system will provide accessible services to people by analysing and comparing Commuters’ Stated-Preferences of the BRT and proposed DART System characteristics. Based on the research findings, conclusions were drawn and recommendations were proposed.
1.5.1. Research Matrix

The table below shows the research matrix, which indicates the data required, sources of data, data acquisition tools and when, and methods of analysis for each question of a specific research objective to be operationalised in order to achieve the main objective of the research.
Table 1-2: Research Matrix

<table>
<thead>
<tr>
<th>No.</th>
<th>Specific Research Objectives</th>
<th>Data required</th>
<th>Data Sources</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>To identify the proposed DART System Characteristics and its spatial coverage.</td>
<td>Relevant literatures, reports on DART system</td>
<td>Secondary /Primary</td>
<td>Literature Review</td>
</tr>
<tr>
<td></td>
<td>DART Network - All phases, Dar Land use map, Socio-economic data</td>
<td>Secondary /Primary</td>
<td>GIS Network Analysis, Statistical Analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DART Network - All phases, Dar Land use map, Socio-economic data</td>
<td>Secondary /Primary</td>
<td>GIS Network Analysis, Statistical Analysis</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>To examine commuters’ attitudes and preferences to use the proposed DART service</td>
<td>List of attributes related to Public Transport modal choice</td>
<td>Secondary</td>
<td>Literature Review</td>
</tr>
<tr>
<td></td>
<td>Residential Zones, Commuters’ income groups, Commuters’ stated preferences</td>
<td>Primary</td>
<td>Stated choice modelling (Binary-Logit Model)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>To assess the proposed DART System characteristics based on commuters’ attitudes and preferences</td>
<td>Residential Zones (TAZ), Commuters’ stated preferences, proposed DART characteristics</td>
<td>Primary</td>
<td>Stated Choice analysis, Statistical Analysis</td>
</tr>
<tr>
<td></td>
<td>DART Network/ Routes- All phases, commuters' stated preferences, Traffic Analysis Zones (TAZ)</td>
<td>Secondary /Primary</td>
<td>GIS Network Analysis, Statistical Analysis</td>
<td></td>
</tr>
</tbody>
</table>

1.6. **Limitations of the Research**

The main limitations of this research are that it considers the BRT as the only public transport mode without competition from other modes (no alternative modes) given that with time the BRT will replace completely the existing public transport modes based on the factual information from the ground (DART Agency). This has led to the use of utility models that has limited analysis to finding utility derived from the BRT and its operational attributes. Therefore, since there will not be alternative modes in competition with the BRT, the issue of discrete choice modelling is considered out of scope of this research.
Secondly, given the hypothetical situation of the BRT, only stated preference data was collected and this might have an effect on the analysis results as literature suggests combining stated and revealed preference data for better realistic results, however, revealed data could not be collected since there is no existing BRT and has never existed before in the study area. Therefore, the model used carries the limitation of stated preference data in this research. In addition, this research is only limited to the proposed BRT and does not study the current public transport situation in the study area.

Another limitation of this research is that it mainly focuses on the proposed BRT main Trunk corridors and does not consider the feeder system. This is because the feeder characteristics were not yet defined clearly and if the feeders were to be considered in this research, then the number of attributes would become too large. Thus, finally the task complexity would become too difficult and more so if one would treat them separately and take them in one choice alternative. Besides that the budget and time constraints would not allow it to be done. However, it would be a better approach to study the BRT main trunk integrated with the feeder system to give an over view of the whole system evaluation. Therefore, further research is recommended to look at the BRT feeder system separately or as an integrated BRT Trunk- feeder system.

The stated preference survey was conducted in residential areas within wards along side the proposed BRT corridors and the surveyed population were commuters who traveled to the CBD on regular basis and therefore the analysis and conclusions drawn from this research is based on their stated views. However, their stated views should not be taken to represent the views of the entire city population.

1.7. **Expected Outcomes of the Research**

- The research gives an insight on how the proposed Dar Rapid Transit (DART) will provide accessible services for all economic groups.
- Information about commuters’ travel attitudes towards the proposed DART attributes is obtained.
- The research gives a proper insight on how commuters value certain travel attributes of a public mode compared to others based on their stated-preferences.
- The research also gives an idea on how and where to improve the Proposed DART system to attain its goal.

1.8. **Benefits of the Research**

Findings in this research will generate the following benefits:

- The DART agency can develop better awareness about the spatial distribution, strength and weakness of their proposed service. Besides they can get ideas on how and where to improve the service.
- It will demonstrate the importance and the potential of stated-preference based survey methods in analysing People’s attitudes towards public transport, which is helpful for transport planners to solve one of the complex urban problems.
- It will provide an opportunity to further research by individuals and organisations.
1.9. Thesis Structure

**Chapter-1** Briefly presents the background and justification for the research, identifies the research problem, defines the research objectives and questions and provides a general overview of how the research aims to achieve the intended objective.

**Chapter-2** Based on literature Survey, this chapter describes and defines the theoretical concepts of accessibility and travel choice behavior where the accessibility measures of public transport are identified and defined and also looks at how these measures influence commuters’ travel choice behavior.

**Chapter-3** Gives general description of the Study Area based on topography, land use, Road Network, Socio-economic Characteristics, current situation of Public Transport and proposed DART System.

**Chapter-4** Presents the methodology and data collection techniques used. It outlines and discusses the methods and data collection techniques used from Pre-field work stage to Post field work stage and shows the Overall data analysis procedure followed.

**Chapter -5** Describes the situation of the proposed Dar Rapid Transit and its attributes and identifies its spatial coverage mainly using GIS and statistical summaries of the analysis

**Chapter -6** Describes the analysis of the commuters’ stated preferences to the proposed DART System and provides discussion of results

**Chapter-7** Gives an assessment of the proposed DART Characteristics based on Commuters’ preferences and provides an insight on the effectiveness of the system.

**Chapter- 8** Presents conclusion and Recommendations based on analysis results.
2. **Accessibility and Travel Behaviour Concepts under Travel Demand Analysis**

2.1. **Introduction**

Travel demand Analysis is an essential element in the analysis of transportation systems. It is concerned among others with accessibility studies that shed light on the spatial distribution of availability and reachability of opportunities; it looks at the spatial coverage of public transit systems and similarly looks at accessibility studies concerned with the behaviour of consumers of transportation services and facilities. The consumers are commuters and shippers of goods in urban, inter-urban and international Transport markets (Ben-Akiva and Lerman, 1985).

Although Accessibility is a common planning objective and frequently used term in urban planning literature, it is a concept that has been defined and operationalised in many different ways. Therefore, first there is a need for a clear insight in the accessibility concept, only then one can investigate how accessibility can be operationalised in the context of this study.

However, urban areas exhibit variations in the spatial distribution of mobility needs. Such variations occur as a result of permutation in population densities, socio-economic, demographic and living conditions which all have an impact on the travel behaviour of people. The existence of spatial variations in the levels of well being of which mobility needs are part within urban areas closely matches the choice behaviour of commuters.

Therefore, accessibility measures based on the use of econometric modelling to predict the behaviour of the commuters, particularly in analysing the attitudes and preferences of the potential users to changes brought about by new services, investments in infrastructure and to changes in operating and pricing policies is an important factor and a key point especially in public transport planning and this research in particular.

The rest of this chapter is organised as follows. Section 2.2 discusses the theoretical concepts and definitions of accessibility and its measures. Section 2.3 discusses the relationship between accessibility and travel behaviour. Section 2.4 reviews the consumer choice behaviour concepts. Section 2.5 details the methodological framework of stated preference methods and examines the major issues in designing reliable SP experiments; lastly, section 2.6 reviews the concept of random utility and its estimation procedures.
2.2. **Accessibility: A concept and Tool for Public Transport Planning**

In urban planning, accessibility is used frequently in explanations of the growth of cities; the spatial location of facilities and functions and their relative position within the entire land use structure whereas in public transport planning context, accessibility is the measure of transport system’s ability to provide low cost service (either in monetary value or time) to overcome the distance between two points (Handy and Niemeier, 1997). Therefore, in public transport planning, accessibility is a major factor that has to be considered and is a much broader concept than mobility and the only one capable of capturing the travel pattern in its entirety; hence an important tool for analyzing transport and traffic policies. Accessibility allows the interaction of people with land use along certain transport mode. According to Geurs and Ritsema (2001) accessibility is defined as the extent to which the land-use transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s) whereas from transport perspective, accessibility of a transport system is the extent to which the system facilitates people’s participation in activities. Hence, accessibility may be defined as the degree of ease with which people get to desired destinations (Geurs and Ritsema, 2001). Being primarily a social measure, accessibility analysis considers social, economic and political difference. Figure 2-1 indicates an accessibility model. The model shows the interaction of people with land use along a certain transport mode at a certain period of time. Its components are transport system, People (individuals), activities (land use and time).

![Accessibility Model](image)

**Figure 2-1: Accessibility Model**
Source: (Geurs and Ritsema, 2001)

Also, Moseley (1979) quoted by (Amer et al., 2007) systematizes accessibility as consisting of three components: (1) People (2) the activities or opportunities that they require, and (3) the transport or communication link between the two. Therefore, proximity, connectivity and mobility have been incorporated in accessibility by arguing that it is a function of land use, transportation networks and services and system performance or quality of movement respectively (Geurs and Ritsema, 2001).

In measuring the performance, quality and level of service of urban services the concept of accessibility has been employed in different forms as an indicator of the guiding principles of equity, efficiency and effectiveness (Amer, 2007). Accessibility measures include a “density” of opportunities enabled by transportation services for example, number of households within a 30-minute drive of key regional centres or number of employment opportunities within a 10-minute walk of transit stops or the ability of a facility to serve a particular user group. Availability of modes and modal choice can also be treated as an accessibility measure (NCHRP, 1997).
2.2.1. An Overview of Accessibility Measures

Geurs and Ritsema (2001) identifies three basic perspectives on measuring accessibility: Infrastructure-based measures usually used in transport studies and infrastructure planning to analyse the (observed or simulated) performance of transport infrastructure. Typical measures are average speed on the road network and level of congestion. Activity-based accessibility measures are used to analyse the range of available opportunities with respect to their distribution in space and travel impedance between origins and destinations. Utility-based accessibility measures are used to analyse the benefits of individuals derive from land-use transport system. Importantly combinations of infrastructure and activity-based measures are also used, especially in urban planning. Typical measures are “Distance from housing locations to public transport infrastructure” or “distance or travel time from working locations to a road way junction”.

For each accessibility measure, different components of accessibility can be identified that is to say the transport component reflecting the disutility that individuals or groups experience in bridging the distance from their origin to destination using a specific transport mode expressed in amount of time, cost and/or effort. A land use component reflecting the magnitude, quality and character of activities found at each destination (e.g. jobs, homes, schools, recreational facilities) and this component’s distribution in space. A temporal component reflecting the availability of opportunities at different times of the day i.e. opening and/or closing hours and the times at which individuals participate in certain activities (e.g. work recreation). Individual component reflecting the needs, abilities and opportunities of individuals. People’s needs depend on characteristics such as age, income, educational level and home situation. Abilities depend on people’s physical state (may depend on age, physical disabilities) and access to transport modes (e.g. possession of a driver’s license and car). Opportunities depend on people’s income, travel budget, education level, etc. (Geurs and Ritsema, 2001).

2.2.2. Identification of Accessibility Measures for Public Transport Planning

Klaassen and Eckman (1980) as cited by (Berhie, 1998) points out that in public transport planning, accessibility should be understood in the following two senses:

- Proximity of individuals to transit stops for basic availability of services. Accessibility in this sense, reflects, the relative locations of individuals to the transit stops for a given or provided service route. It is a measure of relative spatial location of individuals to the transport network or elements of the network (Transit stops). It is often measured by walking distance to transit stops, or stations.

- Attainability of desired destinations by individuals throughout the transit network. This sense contains a spatial dimension of the ease with which individuals can reach desired destinations. This depends on the level of service of the transport system.

2.2.2.1. Proximity of Individuals to stops and Network

Proximity of individuals to public transport network can be measured in two ways: directly by measuring the walking distance of users’ origin to the nearest point at the public transport service or
by looking at the route density of an area at a higher level. However, the latter is beyond the scope of this study and thus walking distance will only be discussed.

**Walking Distance to bus stops**

Proximity to stops is a measure of opportunities of individuals to use the public transport service within a minimum acceptable standard walking distance from their origin to any transit stops on the network. Basically the level of accessibility is more realistic when it is measured in this method because the real walking distance is the distance from origin to nearest stop rather than to the network line since individuals are supposed to take the bus from the stop not from any point on the network. So a larger number of stops suggest a better level of accessibility. Proximity to transit stops however, has a shortfall that it does not measure attainability of destinations or the easy with which an individual can travel to many directions.

Walking distance to bus stops is the distance that commuters have to walk to and from the bus stops. It is an indicator of the spatial coverage of public transport system. For well-served urban areas it should be in the range of 300 metres (m) to 500 metres (m) from home or work place. Distance in excess of 500 m may be acceptable in low density area but the maximum should not exceed 1000 m (Armstrong-Wright et al., 1987). However, in developing countries Rastogi and Rao (2003) found from their study that commuters still preferred walking up to a distance of 1,250 metres.

**2.2.2.2. Attainability of desired destinations**

Attainability of desired destinations is how reachable an area is from another area by public transport. Attainability of destinations from a certain point depends on the characteristic and nature of the link between the two points. Generally, it is determined by performance and level of service of the public transport. However, only the level of service will be discussed in this study since performance is out of the scope of the study in this particular research.

**Level of Service**

Level of service is the most complex aspect as it covers the quality and effectiveness of the transport network, the distribution of transit stops, route distribution and vehicle operation.

1. **Effectiveness:** the extent to which public transport system achieves its public policy objectives, which is provision of transport service accessible for the urban community within an acceptable maximum walking distance and reasonable cost. It also includes vehicle operating speed, frequency, capacity in terms of ability in transporting greater number of commuters, route density, and area coverage of transit system.

2. **Quality of service:** It refers to the level of comfort the service offer during travel. To be able to improve the quality of the public transport system it is necessary to know which attributes determine the quality and to what extent the attributes are effective in indicating it. Quality includes many attributes for each trip made by public transport ranging from the access time to the nearest bus stop and the availability of seats at interchanges, to the air conditioner inside buses. Although all attributes determining quality do not equally contribute to the total quality of the trip made, but most of them are often common. The attributes given below are supposed to indicate the quality of the trip made by public transport.
   - Total time taken to travel from origin to destination including walking and waiting time;
• Existence of seats; Air conditioner; Shades and seats at stops.
• Facilities in the transfers like waiting areas, shops, ticket selling areas and others.

Waiting time is the time commuters have to wait at bus stops for buses. Longer waiting times indicate poor adequacy. In developing countries, to achieve a reasonable level of service, the average waiting time should be in a range of 5 to 10 minutes, with a maximum waiting time of 10 to 20 minutes under the prevailing conditions (Armstrong-Wright et al., 1987).

Total time: is the total time spent to reach a destination from a given origin. It should not be more than two to three hours per day (Armstrong-Wright et al., 1987).

Temporal Accessibility

Temporal accessibility is a measure of how reachable an area is from other areas in terms of travel time. To apply this measure there must be an agreement on determining the most important location that the greater number of the community needs to travel frequently. For example, if the CBD is considered to be the reference location, then after computing the travel time from and to the CBD for the whole residential areas; those areas with least travel time would be considered as good accessibility. This method can only measure the vehicle operation efficiency. Factors affecting temporal accessibility are:
• Distance; traffic congestion and road quality; efficiency of operation; availability of enough vehicles(Frequency); number of transfers

The total temporal accessibility of an area is the sum of: walking distance (in time) to and from transit stop; waiting time for vehicles on route (including transfers); in-vehicle travel time.

Thus, to improve temporal accessibility of a certain point in a city, each of the above time components should be treated.

2.3. Accessibility and Travel Choice Behaviour

It has long been understood that the interaction between two locations declines with the increasing disutility (distance, time and costs) between them. In general the perception and valuation of the distance between an origin and a destination differ according to: Transport modes i.e. car, public transport, non- motorised modes; purpose of trip e.g. home-work, non-home work, social; characteristics of household e.g. Income, educational level; Characteristics of destination i.e. its uniqueness and attractiveness (Zuidgeest and Maarseveen, 2007b).

However, this difference in perception and valuation of individuals based on their travel behaviour characteristics may be difficult to investigate unless utility- based accessibility measures are employed. Utility-based accessibility measures are used to analyse the benefits of individuals derive from land-use-transport system and thus forms the foundation of this study.

2.3.1. Utility- Based Accessibility Measures for Public Transport

Accessibility measured based on utility are founded in economic theory. Utility- based accessibility measures interpret accessibility as the outcome of a set of transport choices. Utility theory addresses the decision to purchase one discrete item from a set of potential choices, all of which satisfy
essentially the same need (Greene and Liu, 1988), and can be used to model travel behaviour and the net benefits of different users of a transport system. The utility-based approach asserts that accessibility should be measured at the individual level and that the computation of individual accessibility should account for users’ characteristics (Banister and Berechman, 2000).

Therefore, Utility-based accessibility approaches assign particular importance to conceptualising the decision process to explain and model individual travel choice behaviour. This type of approaches is mostly operationalised using discrete choice models. These models are generally rooted in random Utility theory in which the probability of an individual making a particular choice depends on the utility of that choice relative to the utility of all choices (Thurstone, 1927) as quoted by (Amer et al., 2007). The expected Choice behaviour is captured using a utility function that reflects the attractiveness of the destination, the travel impedance, and the socio-economic characteristics of the individual, and their tastes and preferences (Borgers and Timmermans, 1993).

The main advantage of utility-based approaches is their solid theoretical foundation in economic theory i.e. the random Utility theory on which these measures are based provides a direct link to traditional micro-economic theory (Geurs and Ritsema, 2001). More to that, the measure has a better behavioural basis than the basic potential accessibility measure, i.e. Utility based measures represent accessibility of individuals at a location, whereas potential accessibility represent accessibility of zone or a location, assuming all individuals in the same location have the same level of accessibility. Another important advantage of utility-based measures is that they do not result into the unrealistic outcomes when aggregating individual accessibility (Geurs and Ritsema, 2001).

On the other hand, the outcomes of a utility-based measure are not easily interpreted by non-specialists and that the formulation can not be explained without reference to relatively complex theories (behavioural models of choice). More to that, it is difficult to compare different utility functions, for example by region or neighbourhood (Handy and Niemeier, 1997). Further more, Sweet (1997) argued that log sum values are difficult to interpret in terms of accessibility, because the log sum gives the total utility associated with an alternative (e.g. the disutility of travel time, cost, walk time to bus stop). As a result it can be difficult to interpret values of logsum in terms of the spatial separation measures involved.

2.3.2. Consumer Travel Behaviour

From economic theory point of view, the basic premise of the theory of consumer behaviour is that an individual will select a bundle of goods over all affordable bundles if it yields the greatest utility (i.e. satisfaction). The individual’s decision making consists of maximizing a utility function $\hat{Y}$:

$$\max (U) = U(X_1, ..., X_n) ; \ Y = P_1 X_1 + ... + P_n X_n$$

Where: $Y =$ Income; $X_1, ..., X_n =$ Goods that are consumed; $P_1, ..., P_n =$ Prices of Goods.

Figure 2-2 below presents the solution of this problem when two types of goods (X1 and X2) are considered. The indifference curve U presents the combinations of X1 and X2 corresponding with a given utility level. The income line Y presents the possible combinations of X1 and X2 corresponding with a given income level. The equilibrium is reached at point E, and represents the point at which the individual’s valuation of the goods is the as the market valuation.
In this basic theory, the assumption is made that Utility is generated by the quantity of goods, while in most cases it is generated by the attributes of the goods. Therefore, the demand for a good depends on its price, characteristics and characteristics of the consumer (Zuidgeest and Maarseveen, 2007a).

However, in case of transport, the ‘good’ being demanded is a certain transport service. The ‘price’ consists of all the perceived costs of the traveller, not only the monetary cost but also other costs of the trip (like time, comfort, and others). Thus, the utility of a trip and therefore the demand for it, depends upon the characteristics of: the trip to be made; the available modes; the individuals making the trips (Zuidgeest and Maarseveen, 2007a)

2.4. Consumer’s Choice Behaviour

Economists often treat the consumer as an “optimizing black box” (McFadden, 1986). Revealed choice behaviour deduced from market research experiments, permit estimation of the mapping from inputs to outputs. Inputs are product attributes, socio-economic characteristics, market information, historical experiences and market constraints. Outputs are purchase decisions, consumption levels and related market behaviour. Economic choice theory is an approach to modelling the black box that is designed to provide quantitative forecasts with well defined statistical properties.

In principle, a market researcher could assess the sales and profitability of alternative product designs and marketing programs using a statistically-determined black box model with sufficiently detailed inputs, without any need to delve into the inner workings of the box (McFadden, 1986). In practice, the natural experiments provided by history are often mute on the effects of innovative product designs and even carefully crafted econometric models based on revealed market are inadequate. One way out for market researchers is to model explicitly the cognitive mechanisms in the black box that govern behaviour, and then use experimental data on consumer attitudes, perceptions and intentions to fit this
model. Then the cognitive response to innovative programs can be simulated. McFadden (1986) in his article describes a path diagram of the decision – making process also shown in Figure 2.3 below.

![Path Diagram for the Consumer Decision Process](image)

**Figure 2-3: Path Diagram for the Consumer Decision Process**  
Source: (McFadden, 1986)

Therefore, in the above figure, terms in ovals are theoretical or latent variables, while those in boxes are observed directly or measured by suitable experiments. Measurable inputs to the decision process are product attributes, information from marketing programs and other sources, historical experience, socio economic factors, and market constraints, including budget and product availability. The direct measurable output of the process is market behaviour; for example product purchases (using a travel mode), brand switching (e.g. travel mode). The critical constructs in modelling the cognitive decision process are perceptions or beliefs regarding the products, generalised attitudes or values, preferences among products, decision protocols that map preferences into choices, and behavioural intentions for choice. For example, a commuter may have perceptions of the level of comfort of alternative travel modes, attitudes regarding the importance of comfort, preferences among specific travel modes and types, a protocol to maximize preference taking into account the opportunity cost of using a specific mode, and a behavioural intention to choose a specific mode type. Perceptions are influenced by product attributes and by marketing information, and perceptions, attitudes, and decision protocols are all influenced by historical experience and socioeconomic factors. Generalised attitudes and perceptions together determine preferences and preferences are translated by decision protocols into behavioural intentions, taking into account constraints on choice (McFadden, 1986).

### 2.4.1. Consumers’ Choice Process

Louviere et al (2000) demonstrates a general order or stages in a consumer’s decision process as summarised in figure 2.4 below. The consumer first becomes aware of needs and/or problems to be solved, which is followed by a period of information search in which he/she learns about products that can satisfy these needs or solve the problems. During search and learning, consumers form beliefs about which products are available to attain their objectives, product attributes germane to a choice and attribute values offered by products, as well as any associated uncertainties. Eventually consumers
become sufficiently informed about the product category to form a utility function (decision rule) which involves valuing and trading off product attributes that matter in the decision. Given a set of beliefs or priors about attributes possessed by product alternatives, consumers develop a preference ordering for products, and depending upon budget and/or other constraints/considerations make decisions about whether to purchase. If they decide to purchase, consumers finally must choose one or more alternatives, in certain quantities and with particular purchase timings.

Figure 2-4: Overview of the consumer’s choice process
Source: (Louviere et al., 2000)

More to that, according to Rastogi and Rao (2002), different theories are in use to increase reliability of forecasts based on SP data. One of them is an approach based on ‘Random Utility Theory’, which assumes that the individual assigns utility to an alternative based on complete information and chooses that alternative, which has maximum utility. This approach is widely used and certain modifications have been made to it to deal with pseudo utilities generated from SP data.

2.4.1.1. Modal choice

The choice of a transport mode is probably one of the most important classic models in transport planning. This is because of the key role played by public transport in policy making. Thus the issue of mode choice, therefore, is probably the single most important element in transport planning and policy making since it affects the general efficiency of travelling to urban areas and the amount of urban space devoted to transport functions (Ortúzar and Willumsen, 1994). It is important then to develop and use models which are sensitive to those attributes of travel that influence individual choices of mode.

2.4.1.2. Factors Influencing Mode choice

The factors influencing mode choice may be classified into three groups:

1. Characteristics of the Trip maker. The following features are generally believed to be important: Car availability and/ or Ownership; Possession of a driving licence; Household structure( young couple, couple with children, retired, singles ,etc); Income; Decisions made elsewhere for example the need to use car at work, take children to school; Residential density.

2. Characteristics of the journey. Mode choice is strongly influenced by:
- The trip purpose for example journey to work is normally easier to undertake by public transport than other journeys because of its regularity.
- Time of the day when the journey is undertaken. Late trips are more difficult to accommodate by public transport.

3. Characteristics of the Transport facility. These can be divided into two categories

- Firstly, quantitative factors such as:
  - Relative travel time: in-vehicle, waiting and walking times by each mode;
  - Relative monetary costs (fares, fuel and direct costs);
  - Availability and cost of parking.
- Secondly, qualitative factors which are less easy to measure, such as: Comfort and convenience; reliability and convenience; Protection, Security.

Therefore, a good mode choice model should include the most important of these factors. Mode choice models can be aggregate if they are based on zonal (and inter-zonal) information and disaggregate models if they are based on household and/or individual data (discrete choice models) which are based on random utility theory. Figure 2.5 below shows the classic four-stage Transport Model used for aggregate demand modelling. The model starts with Trip generation where the collected socio-economic and land use data is used to estimate a model of the total number of trips produced or attracted to each zone of the study area: The trip distribution model which allocates these trips to particular destinations where a trip matrix is produced. The following stage is modelling modal choice (split) by use of a logit model which refers to the S-shaped logit curve. Apart from use of the logit curve, discrete choice models which use the theory of utility are used and this model is the one borrowed in view of this research. The last stage of the classic model requires assignment of the trips by each mode to their corresponding networks (Ortúzar and Willumsen, 1994). Therefore this research is limited to the third stage of the classic model (i.e. modal split) by use of discrete choice based on utility theory where the utility generated from the attributes of the transportation service (like BRT) or network is modelled.

Figure 2-5: The classic four-stage transport model
Source: (Ortúzar and Willumsen, 1994)
2.5. Methodological framework: Stated Preference (Choice) Analysis

A fundamental premise of economic science is that consumers have well-informed, stable preferences, and that their choices reflect these preferences. If this is true, then it is possible to deduce from choice behaviour, or from carefully phrased questions about preferences, whether transportation improvements or other public policy initiatives are socially desirable (McFadden, 1997).

In practice, Consumers make errors in perception and judgement that violate classical economic rationality. It is often still possible to use observed behaviour to judge the social desirability of improvements, however, additional problems arise for measurement and analysis. Thus, Transportation Planners are increasingly using Stated choice methods for understanding the unpredictable behaviour of a commuter under conditions that are new or hypothetical (Rastogi, 2000).

2.5.1. Behavioural Foundations of Stated Choice Methods

Stated Choice methods have their behavioural foundations in market research and thus different choice behavioural theories taken to be foundations of stated choice. The term Stated choice method as used in this research, refers to a flexible approach to collecting preference data (generally, choices and rankings, whether full or partial) from subjects in hypothetical situations (Adamowicz et al., 1998).

Adamowicz et al. (1998) states these behavioural theories as: Lancastrian consumer theory which proposes that utilities for goods can be decomposed into separable utilities for their characteristics or attributes; Information processing in judgment and decision making in psychology and Random utility theory, which forms the basis of several models and theories of consumer judgment and decision making in psychology and economics (Thurstone, 1927).

Individuals or decision makers come to recognize a need to solve problems, make choices, or obtain benefits, which initiates search and learning to find out what solutions are available to meet needs. However, environmental conditions and human actions impact individual perceptions of the positions that various alternatives occupy on a set of key decision dimensions (attributes) on which individuals base their evaluations and comparisons. Given descriptions of alternatives on key attributes, Stated Choice methods allow one to understand and model how individuals evaluate product attributes and choose among competing offerings (Adamowicz et al., 1998).

2.5.2. Advantages of Stated Choice Methods

According to Adamowicz et al.(1998), the advantages of using SCM are manifold: (1) control of the stimuli is in the experimenter’s hand, as opposed to the low level of control generally afforded by observing the real marketplace; (2) control of the design matrix yields greater statistical efficiency and eliminates collinearity (unless explicitly built into the design); (3) more robust models are obtained because wider attribute ranges can be applied than are found in real markets; (4) introduction and/or removal of products and services is straightforwardly accomplished, as is the introduction of new attributes. However, the last point in fact is often practically impossible, but certainly always difficult in actual markets. Thus, Stated Choice Methods are not a theory of behaviour; rather, they are simply a means to generate behavioral data from consumers (Adamowicz et al., 1998).

Well-established consumer choice theories and econometric modeling techniques can be applied to such data, just as they are applied to Revealed Preference data (Adamowicz et al., 1998). However, McFadden(1986) reveals that as with any experiment, one can ask if laboratory behaviour is a good
predictor of field behaviour. Good experimental technique can remove most obvious sources of incongruity, but only field validation is fully convincing.

Figure 2.6 outlines SP methods that have been employed in marketing, transportation, economics and other research fields. This figure illustrates that Stated Choice method is one form of SP methods under which Attribute-based stated choice method based on random utility theory is classified. In this research the focus is on Attribute Based Stated Choice Method, since this method has been employed to evaluate the attributes of the proposed BRT system in Dar salaam. Hence the methods shown in red squares are the core in view of this research and thus have to be discussed in detail.

![Figure 2-6: Stated Preference Methods](image)

The above figure 2.6 indicates methods in which respondents are asked to express their preferences for each option offered to them. There are three main ways of collecting information on preferences about alternatives, i.e. asking respondents to rank them in order of preference, to rate them on an arbitrary scale or to choose between them in Choice experiments. Other methods have also been tested, but these are the most frequently employed (Adamowicz et al., 1998; Hensher et al., 2005; Louviere et al., 2000; Ortúzar and Willumsen, 1994)

1. **Ranking Responses**
   This approach presents all the options at once to the respondents and they are asked to rank them in order of preference thus implying a hierarchy of utility values. The main attraction of this approach is that all options are presented together but this also limits the number of alternatives that can be considered without fatiguing the respondent. Furthermore, the researcher needs to be aware that the data provided by this method represent judgements by respondents that do not necessarily correspond to the type of choices they face in real life.

2. **Rating Responses**
   Rating techniques have been used for many years in market research. In this case respondents are asked to express their degree of preference for an option using an arbitrary scale, often between 1 and 10, with specific labels attached to key figures, for example 1 = “strong dislike”, 5 = “indifference” and 10 = “strong preference”. However, it has been shown that responses are not independent from the scales used and the labels attached to them. There is no evidence, therefore, that individual preferences can be usefully elicited and translated into cardinal scales of this type.
3. Stated Choice
Choice experiments require the respondent to select an option either from a pair (binary choice) or a group of them. In its pure form, the respondent only chooses her preferred alternative thus expressing the choice in terms analogous to a revealed-preference survey. In its extended form the respondent is allowed to declare her preferences in a rating scale.

Therefore, the above Stated Choice Methods are implemented through conducting stated preference field surveys which are further discussed in the following section.

2.5.3. Stated Preference (SP) Surveys
Stated Preference Surveys are surveys of actual or potential users of a defined problem, in which respondents are asked to express an attitude or make a choice as how they would act under certain conditions. Stated Preference surveys can have a wide range of uses in transport planning, market research and other research fields and such research questions can be asked (Zuidegeest and Muizelaar, 2007).

- What is the effect of a new system or service in terms of market share, travel demand, etc?
- What is the effect of changing attributes of a system or service?
- What are the important attributes of a system or service and how important are they?

The level of sophistication involved in stated preference surveys can vary significantly. At basic level, survey results can be used directly to prioritise projects or to estimate the impacts of an improvement. Alternatively, more sophisticated surveys can be developed which can be used alone or in conjunction with other data to develop quantitative models of behaviour.

There are two levels of stated preference surveys as identified and stated by the (U.S Department of Transportation, 1999).

1. “Attitudinal” surveys which ask respondents directly how they would respond to various actions or ask them to rate or rank their preferences for various improvements. These surveys are relatively easy to design and implement and have been widely used to estimate the potential impacts of transport system improvements and to determine relative preferences for such improvements. However, attitudinal surveys often significantly over estimate the response to transport system improvement, since people tend to be more likely to state that they will change their behaviour than they actually do so. Attitudinal Surveys tend to be better suited for evaluating relative preferences and for estimating the maximum possible response to an action, rather than predicting actual shifts in travel demand.

2. “Hypothetical choice” surveys overcome many of the biases of attitudinal surveys by requiring respondents to make choices between hypothetical alternatives with varying attributes. Hypothetical choice surveys are generally used to develop discrete choice models and to estimate the relative importance of each attribute in relation to one another. While hypothetical choices, combined with discrete choice modelling, are becoming more widely used travel demand analysis, they have the demerit of requiring considerable time and expertise to implement. The choice of alternatives to be presented to each respondent must be made carefully to provide the desired relationships between the characteristics of the hypothetical alternatives and the possibilities of choosing each alternative.

2.5.3.1. Assumptions of SP Surveys
The Use of stated preference surveys to estimate behaviour changes assumes that people are able to accurately predict their response to a system improvement or policy change. Frequently, when people
are asked if they will change their behaviour in the future, the responses significantly over predict the number of people who actually change the behaviour (Ortúzar and Willumsen, 1994; U.S Department of Transportation, 1999). Therefore, attitudinal surveys that simply ask people how they will respond in a given situation are not generally viewed as reliable (although they can at least give some indication of the relative response to various actions). This problem can be largely eliminated through the use of carefully designed hypothetical choice experiments, combined with data on actual behaviour if available, although respondents may still not be able to accurately judge what their true actions would be if faced with a real world situation (Ortúzar and Willumsen, 1994).

2.5.3.2. Applicability of SP Surveys to diverse conditions
A survey designed for a specific situation cannot be adapted to a wide range of conditions. On the other hand, if data from existing surveys are used, it may not be safe to transfer the results of one survey from one situation to another. When people are asked how their behaviour will change as a result of an action, their responses depend on a number of factors specific to the decision in question, which may not be measured in the survey.

Designing surveys and using survey results represent a trade-offs. The more specific the questions on the survey to the situation being analysed, the more accurate the results are. On the other hand, the survey will be less applicable in different situations, and if a different situation is to be analysed, new survey efforts may be required (U.S Department of Transportation, 1999).

2.5.3.3. Limitation of SP Surveys
The major shortcoming of SP surveys is that it cannot be ensured that the respondent will behave as perceived during the study. Thus the amount of faith one can put on individuals actually doing what they stated they would do when the case arises (for example, after introducing a new option) is a very basic problem with SP data collection (Ortúzar and Willumsen, 1994).

2.5.3.4. Revealed Preference (RP) versus Stated Preference (SP) Surveys
Revealed preference surveys are used to observe actual behaviour, for example trips made by household members, rather than asking respondents how they would behave in a hypothetical situation. Travel behaviour as observed in revealed preference survey is then related to various characteristics which influence travel decisions (Ortúzar and Willumsen, 1994). Thus the basic shortcomings of SP surveys are not present in RP surveys as they deal with existing actual situations being experienced by the user, however, their general suitability is restricted (Ortúzar and Willumsen, 1994; Rastogi, 2000; Rastogi and Rao, 2002), the reasons being:

- Observations of actual choices may not provide sufficient variability for constructing good models for evaluation and forecasting.
- The observed behaviour may be dominated by a few factors making it very difficult to detect the relative importance of other variables. This is a particular problem with secondary qualitative variables like public transport information services, security; but these attributes cost money and it is better to find out how much commuters value them before allocating resources to them.
- RP data cannot be used in direct way to evaluate demand under conditions, which do not yet exist or in collecting responses for policies which are entirely new for example a complete new mode (perhaps a Bus Rapid Transit).
RP data require that the explanatory variables can be expressed in objective or engineering units. Hence they are normally used for primary service variables and are rarely used to evaluate the effect of changes in secondary variables.

By definition, RP data are generally limited to helping researchers understand preferences within an existing market and technology structure. In contrast, although also possibly useful in this realm, SP data provide insights into the problems involving shifts in technological frontiers. This can be illustrated by figure 2.7 below.

**Figure 2-7: The Technological frontier and the roles of RP and SP data**
Source: (Louviere et al., 2000)

Shifts in technological frontiers are at heart of most academic and applied research in marketing, transportation particularly issues related to demand for new product introductions and many others. Forecasts of likely demand, appropriate target markets, segments and the like are often needed to develop appropriate corporate and marketing strategies. Both Government and Business need reliable and valid models to reduce uncertainties associated with such decisions, which in turn have encouraged the development of various SP methods and models. Although the positive features of SP data were emphasized, it is important to note that the two data sources (RP and SP) are generally complementary, so that the weaknesses of one can be compensated by the strengths of the other thus recognition of this complementarity underlies the growing interest in combining RP and SP choice data in transportation and marketing studies (Louviere et al., 2000). The basic points of differences between the RP and SP information are summarized (Rastogi, 2000; Zuidgeest and Muizelaar, 2007) in Table 2.1 below.
<table>
<thead>
<tr>
<th>Factor</th>
<th>RP</th>
<th>SP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preference</td>
<td>Observed in real markets (world as it is now)</td>
<td>Observed in hypothetical situations or virtual decision contexts</td>
</tr>
<tr>
<td>Alternatives</td>
<td>Have only existing alternatives as observables</td>
<td>Can include existing and or proposed and/or unlabelled choice experiments.</td>
</tr>
<tr>
<td>Attributes</td>
<td>Possess inherent relationship between attributes (technological constraints are fixed).</td>
<td>Control relationships between attributes, which permits mapping of utility function with technologies different from existing ones</td>
</tr>
<tr>
<td>Choice set</td>
<td>Ambiguous in many cases</td>
<td>Pre-specified</td>
</tr>
<tr>
<td>Degree of Responsiveness</td>
<td>Embody market and personal constraints on the decision maker</td>
<td>Can not easily respond to changes in market &amp; personal constraints effectively.</td>
</tr>
<tr>
<td>Reliability</td>
<td>Have high reliability and face Validity</td>
<td>Seem to be reliable when respondents understand, committed and can respond to Tasks.</td>
</tr>
<tr>
<td>Number of responses</td>
<td>Yield one observation per respondent at each observation point</td>
<td>Usually yield multiple observations per respondent at each observation point</td>
</tr>
<tr>
<td>Response Format</td>
<td>Preference information available is “choice”</td>
<td>Various response formats(Choice, ranking, rating) are obtainable</td>
</tr>
</tbody>
</table>

Table 2-1: Comparison of Revealed Preference and Stated Preference information
Source: (Louviere et al., 2000; Rastogi, 2000; Zuidgeest and Muizelaar, 2007)

2.5.3.5. Main features of an SP Survey

(Louviere et al., 2000; Ortúzar and Willumsen, 1994) summarizes the main features of an SP survey as follow:

- It is based on the elicitation of respondents’ statements of how they would respond to different hypothetical (travel) alternatives.
- Each option is represented as a package of different attributes like travel time, fare, headway, reliability, comfort and others.
- The researcher constructs these hypothetical alternatives so that the individual effect of each attribute can be estimated; using experimental design techniques that ensure the variations in the attributes in each package are statistically independent from one another.
- The researcher has to make sure that interviewees are given hypothetical alternatives they can understand, appear plausible and realistic, and relate to their current level of experience.
- The respondents state their preferences towards each option by ranking them in order of attractiveness, rating them on a scale strength indicating preference or simply choosing the most preferred option from a pair or a group of them.
- The responses given by individuals are analyzed to provide quantitative measures of the relative importance of each attribute; in most cases choice models can be estimated.

Ortúzar and Willumsen (1994) states that the power of an SP exercise lies in the freedom to design quasi-experiments to meet the requirements of a research need. This power has to be balanced by
the need to ensure the responses provided by the subjects are realistic, that is as close as possible to how they would have responded had these hypothetical options actually existed in practice. This balance must be struck at different stages in the SP exercise:

- Identification of the key attributes of each alternative and construction of the choice sets(packages) constituting the options; all essential attributes must be present and the options must be plausible and realistic;
- Design of the way in which the options will be presented to the respondents and how they will be allowed to express their preferences; the form of presentation of the alternatives must be easy to understand and within the context of the respondents experience and constraints;
- Development of a sampling strategy to be followed to ensure a rich and representative data set;
- Appropriate conduct of the survey including supervision and quality assurance procedures;
- Use of good model estimation techniques, ideally combining SP and RP data having in mind the way in which the resulting weights or models will be used to assist in decision making.

2.5.3.6. Processes in Setting up stated choice experiments

The foundation for any SP experiment is an experimental design. An experiment defined in scientific terms involves the observation of the effect upon one variable, a response variable, given the manipulation of the levels of one or more other variables (Hensher et al., 2005). The manipulation of the levels of variables does not occur in a haphazard manner, but turns to a specialised form of statistics to determine what manipulations to make and when to make them. Thus the manipulations occur by design, hence the name experimental design (Hensher et al., 2005).

In the experimental design literature, the manipulated variable is called a factor, and the values manipulated are called factor levels. Such variables are also referred to in various disciplines as independent or explanatory variables, or attributes and the values manipulated attribute levels when they are features or characteristics of products and services (Louviere et al., 2000). Thus, for the case of this particular research, the term attribute and attribute levels will be used. Each unique attribute level is also termed a ‘treatment’, or if more than one attribute is manipulated, each combination of attribute levels is called a ‘treatment combination’. A designed experiment is therefore a way of manipulating attributes and their levels to permit rigorous testing of certain hypothesis of interest. In the general case of Stated choice models, the hypothesis of interest typically concern terms in utility and choice models. More generally, the term design, refers to the science of planning in advance exactly which observations to take and how to take them to permit the best possible inferences to be made from the data regarding the hypotheses of research interest (Louviere et al., 2000). Designed experiments can be very simple, involving as little as one attribute level and an associated control condition in which there is no discount. The design aspect deals with planning the experiment in such way that as many other influences as possible can be ruled out. Figure 2-8 shown below summarises the process used to generate stated choice experiments.
This process begins with a refinement of the problem, to ensure that the analyst has an acute understanding of what the research project hopes to achieve by the time of completion. Once the problem is well understood, the analyst is required to identify and refine the stimuli to be used within the experiment. It is in this stage of the research that the analyst decides upon the list of alternatives, attributes and attributes levels to be used. This refinement may result in further scrutiny of the problem definition, and as a result return to the problem refinement stage of the process. Moving from stimuli refinement, the analyst must now make several decisions as to the statistical properties that will be allied with the final design (Hensher et al., 2005).

Importantly, the first two stages of the process consist of refining the analyst’s understanding of behavioural aspects of the problem as they relate to decision makers. It is hoped that this understanding of behavioural impacts will regulate the decision process of the analyst at the time of considering the statistical properties of the design. Often, however, statistical considerations must take precedence. Statistically inefficient designs, designs which are unwieldy in size, or possibly even the non-availability of a design that fits the behavioural requirements established in the earlier stages, may trigger a return to the first two stages of the design process (Hensher et al., 2005).

Provided the analyst is through with the above steps, the experimental design may be generated. While it is preferable to generate such designs from first principles, such derivation requires expert knowledge. Statistical packages such as SPSS are capable of generating simple experimental designs. Following the generation of the experimental design, the analyst must allocate the attributes selected in stage 2 to specific columns of the design. Again, a return to previous stages of the design process may be necessary if the design properties do not meet the criteria established at earlier stages of the process (Hensher et al., 2005).
Once the attributes have been allocated to columns within the design, the analyst manipulates the design to produce the response stimuli (i.e. choice). Thus, in stage 6 of the design process, the analyst construct choice sets that will be used in the survey instrument (e.g. a questionnaire). To overcome possible biases from order effects, the order of appearance of these choice sets are randomised across questionnaires. As such several questionnaire versions are created for each single choice experiment undertaken. The final stage of the experimental design process is to construct the survey, by inserting the choice sets as appropriate into the different versions and inserting any other questions that the analyst may deem necessary to answer the original research problem. Thus such questions on Revealed preference data and socio-demographic characteristics may be asked (Hensher et al., 2005).

Therefore, an overview of the effort necessary to conduct stated choice study is discussed under the following steps below:

1. **Characterization of the decision problem**: This is a most important stage of the study. Through focus groups, literature search, interviews with experts, etc., the study team seeks to characterize the decision problem in terms that the decision maker understands. Specifically, Analysts need to understand how individuals (i) become aware of the need to make the decision in question, (ii) define the dimensions of evaluation of the product or service, (iii) search for information on alternatives and attributes, (iv) construct choice sets, and (v) make decisions. These items are crucial in formulating a decision problem that is most akin to the decisions that individuals make in real life, when the selection problem of interest is one relatively familiar to decision makers. When the choice being studied is less familiar to the respondent, this stage maximizes the analyst’s chances of communicating the desired information to him or her. Analysts also seek to identify sources of individual heterogeneity (e.g. income, education, attitudes towards public transport) that could lead to important behavioural differences. Although, identifying and controlling for heterogeneity is important, it is necessary to recognize that there will always be a chance that unidentified factors are influencing preference parameter estimates. The basic outputs of this stage are four: (i) choice set size and composition, (ii) relevant attributes, (iii) individual differences and (iv) relevant sampling frame for the study (Adamowicz et al., 1998).

2. **Attribute level selection**: Based on study objectives and the above Step 1 information, the number and value of the levels for each attribute must be defined. This stage of the study is often conducted in parallel with Step 1, since even the language for communicating levels to individuals is often an issue. An important consideration at this stage is to be sure not to hamstring subsequent analyses due to an excessively limited range for the attributes. Commonly, attributes are identified from prior experience, secondary research and/or primary, exploratory research as discussed by (Hensher et al., 2005; Louviere et al., 2000). After identifying the attributes for a particular experiment, the analyst must assign values or levels to each attribute. These levels should be chosen to represent the relevant range of variation in the present or future market of interest. Though commonly presented in words and numbers, attribute levels may be communicated via pictures (static or dynamic), computer graphics, charts, etc. To the extent that visual (rather than text) representations of attribute levels are utilized, it is likely that respondents will perceive levels more homogeneously, likely leading to more precise parameter estimates in the modeling stage. The trade-off, of course, is that non-textual presentation of information is costly and (often) time-consuming to produce.
3. Experimental design development: Once attributes and associated levels have been determined, analysts typically use some form of orthogonal design to generate different combinations of attribute levels called “treatment combination” in the statistical design literature (Hensher et al., 2005; Louviere et al., 2000). A “treatment combination” is a single attribute level combination in a complete factorial combination of attribute levels. A “design” is a sample of profiles which have a particular set of statistical properties that determines the utility specification(s) that can be estimated (i.e. identified). The overwhelming majority of experiments in which consumers express preferences for attribute level combinations presented one-at-a-time make use of orthogonal arrays called "main effects plans". A main effects plan is an orthogonal subset of the complete factorial which allows an analyst to estimate a strictly additive, "main effects only" (no interaction terms) utility specification. That is, one must know or assume that all interaction effects between attributes are not significant (Adamowicz et al., 1998); if this assumption is not satisfied, the use of main effects models can lead to unknown and potentially large bias in the utility parameters that are estimated. Main effects plans are unlikely to be appropriate in many choice contexts. Their popularity seems to arise from (i) a perceived need to model individuals to avoid aggregation biases, and (ii) insufficient training in statistical design theory, which results in over reliance on design catalogues and computerized design generators (Adamowicz et al., 1998).

4. Questionnaire development: The questionnaire is usually a paper and pencil task that is either self-administered or presented through an interviewer. While its main content will be one or more choice scenarios through which the respondent will be guided, it may also include sections requesting socio demographic, economic, attitudinal and past behaviour data. This last item (past behaviour data) may be of particular interest if one intends to combine RP data with Stated Choice results. Researchers not only have to collect information on what the individual actually did (e.g. where he/she travelled), but also what other alternatives were considered, and if necessary, the characteristics of both chosen and non-chosen alternatives. As in any survey based research, pre-testing of the questionnaire through piloting is a necessary component of the research program. However, differently from survey based tasks, SP experiments require that the analyst define how many choice scenarios (i.e. replications) each respondent will be asked to do. While there are no hard and fast rules, the analyst must balance respondent learning and fatigue against efficient use of the respondent. There is contradictory evidence about the impact of the task length on the quality of data provided by respondents (Adamowicz et al., 1998).

As a practical matter, Analysts usually submit a respondent to about eight choice scenarios. However, as little as one and as many as sixteen (or very occasionally, even thirty-two) scenarios may be given to an individual. There has been little systematic analysis of the impact of varying the number of choice alternatives on individuals. Furthermore, there is little analysis that Analysts are aware of on non-response bias in Stated choice methods, either item-non response or survey-non-response(Adamowicz et al., 1998).

5. Sampling Strategy: The usual considerations of desired accuracy levels versus data collection costs must guide definition of sample sizes. In addition, if one is estimating models that account for individual differences, one may have to impose minimum sample size requirements within segment to enable accurate predictions within segment. From his article Adamowicz et al.(1998), it is indicated that with as few as six respondents per choice scenario, the asymptotic properties for maximum
likelihood-based inference are satisfied. While the above general principles are applicable, in Stated choice experiments total sample size will be further affected by the total number of choice scenarios and the number of choice alternatives in a given scenario.

Also as stated by Ortúzar and Willumsen (1994) SP experiments are statistically efficient, in the sense that each interviewee produces not just one observation but several on the same choice context. It is suggested that 75-100 interviews per market segment might be sufficient. However, part of the difficulty lies in the nature of the information collected in SP surveys. The fact that each interview may result in 10 or more stated responses to the same number of hypothetical choice situations provides information about the variations in responses within each individual. However, for a good representative model, one needs to incorporate the variations that occur between as well as within individuals and only an adequately sized and representative sample can do this (Ortúzar and Willumsen, 1994).

The problem of sample representativeness may be complicated in SP contexts, precisely because of the additional flexibility offered in principle by the approach (the analyst can control the contexts). For example, if a set of individuals of a very well defined type (say frequent users of a given service) are asked about in mode comparisons of service improvements, it is possible to ensure more easily that the survey context is relevant to all respondents (i.e. that the options posed are technologically feasible). However, a model estimated with this data will be able to provide little evidence about the behaviour of other groups, such as new users, which might be attracted by the same service improvements. Therefore, to forecast demand it is thus necessary to survey many types of individuals in order to obtain representative results. If one samples randomly, one may require large samples in order to achieve an adequate number of observations about minority choices (Ortúzar and Willumsen, 1994).

6. Model estimation: The econometrics, transportation, marketing and resource economics literatures abound in examples of stated choice model estimations. The most common model estimated has been the Multinomial Logit (MNL), and the most common estimation criterion is maximum likelihood. However, there are also examples of other choice model specifications (e.g. Multinomial Probit, Nested MNL) being applied to stated choice data. If data fusion (i.e. combination of multiple data sources) is being performed, the estimation may involve both revealed and stated preference data (Adamowicz et al., 1998; Ortúzar and Willumsen, 1994).

7. Decision Support System (DSS) development: This step is quite idiosyncratic and specific to each study. However, in general, there is the need to embed the estimated choice model in a computerized tool that enables analyses to be easily performed. Though seemingly trivial, this step can be essential in making results (more readily) accessible to non-technical parties. This transparency may be of special interest in the case of transport system assessments, when increased access may translate into increased acceptance and confidence in the analysis results (Adamowicz et al., 1998).

2.5.3.7. Stated choice Survey Design

As stated earlier Stated Preference surveys are the vehicle by which SC experiments are implemented. By "survey" one means any vehicle by which scenarios and other questions are presented and/or asked, and responses and/or answers obtained. Thus, a survey can be a "paper and pencil" presentation of questions and choice sets, or it might be a full-blown multimedia event in which full-motion video
and real-time audio and/or virtual reality are used to simulate different experimentally designed environmental scenarios as realistically as possible. Similarly, a "survey" can be administered by mail, personal interview or even via the Internet or other integrated network, like a dedicated cable channel (Adamowicz et al., 1998). Basically, SP surveys typically consist of a glossary or similar section which provides basic information about the context, the attributes, the levels of the attributes, etc. The choice task itself is preceded by a set of standardized (for that task) instructions to subjects regarding the task, its objective, its context and how to respond to the scenarios. The task itself follows the instructions, and depends largely on the decision to be simulated and the research objectives. Thus, a task can be as simple as a yes/no response to scenarios containing single alternatives presented one-at-a-time, pairs of alternatives plus the option of not choosing, multiple alternatives with a no-choice option, and many variations thereof. In general, the task should be designed to simulate the actual choice and choice context as closely as possible. The scenarios typically appear in a random order, but there are no research results to provide guidance as to whether the ordering can be a) a single random ordering for all subjects, b) multiple random orders to which subjects are assigned, or c) separate random orders for each subject. Recently, however, Brazell and Louviere (1997) as quoted by (Adamowicz et al., 1998) found no differences due to order, even in very lengthy tasks, except for differences in reliability: generally, shorter tasks were more reliable, but unreliability increased slowly with task length for numbers of scenarios that would be considered in applications (i.e. eight to 48).

2.5.3.8. Information Presentation

Information in Stated choice surveys refers to the alternatives and the attributes. This information can be purely verbal, purely visual, a combination of verbal and visual, multimedia, etc. The way in which information is presented depends on the problem and research objectives, as well as the resources available. The more realistically scenarios can be depicted, the better, which means that generally speaking, the trend has been increasingly to move in the direction of multimedia events when high levels of accuracy and reliability are demanded. The way in which the information is presented also can vary substantially: verbal attribute information can be presented as a list of bulleted or highlighted items with the levels represented by short descriptors. Alternatively, such information can be presented in paragraph form. Generally, a picture or a graphic rendition is worth many words, especially if the words can be interpreted differently by different subjects. Thus, the trend has been to provide pictures, graphics, video, audio, etc. (Adamowicz et al., 1998; Rastogi and Rao, 2002)

2.6. Estimation of Random Utility Models

The most common theoretical base for generating discrete choice models is the random utility theory (Ortúzar and Willumsen, 1994) which basically postulates that:

1. Individuals belong to a given homogeneous population \( Q \), act rationally and possess perfect information i.e. they always select that option which maximizes their net personal utility subject to legal, social, physical and/or budgetary (both in time and money terms) constraints.

2. There is a certain set \( A = \{A_1, A_2, \ldots, A_j, \ldots, A_n\} \) of available alternatives and a set \( X \) of vectors of measured attributes of the individuals and their alternatives. A given individual \( q \) is endowed with a set of attributes \( x \in X \) and in general will face a choice set \( A(q) \in A \)
3. Each option $A_j \in A$ has associated a net utility $U_{jq}$ for individual $q$. The modeler, who is an observer of the system, does not possess complete information about all the elements considered by the individual making a choice; therefore, the modeller assumes that $U_{jq}$ can be represented by two components:

- A measurable, systematic or representative part of utility $V_{jq}$ which is a function of the measured attributes $x$; and
- A random part $\varepsilon_{jq}$ which reflects the idiosyncrasies and particular tastes of each individual, together with any measurement or observational errors made by the modeller.

Thus the modeller postulates that:

$$U_{jq} = V_{jq} + \varepsilon_{jq} \tag{2.1}$$

Where $U_{jq}$ is the utility of the $j$th alternative for the $q$th individual.

Which allows two apparent “irrationalities” to be explained: that two individuals with the same attributes and facing the same choice set may select different options, and that some individuals may not always select the best alternative (from the point of view of the attributes considered by the modeller).

$V_{jq}$ is subscripted $q$, even though $V$ is defined as representative, because the levels of attributes contained in the expansion of $V_{jq} = \left( \sum_{k}^{k} \beta_{jk} x_{jq} \right)$ can and often do vary across individuals. The $\beta$s are utility parameters, initially assumed to be constant across individuals. That is, only utility parameters are independent of $q$ (not attribute levels). Utility parameters can be allowed to vary across the sampled observations (as random parameters) or be expressed as a function of contextual influences such as socio economic characteristics of an individual or the nature of the data being analysed.

The partitioning of the utility function is used for operation reasons when populations of individuals are modelled. That is, one assumes that one part of the utility is common to all individuals while the other is individual specific. This is a crucial assumption, implying that the existence of a significant element of the full attribute set is associated with homogeneous utility across the population under study. That is, one element, $V_{jq}$, is assumed homogeneous across the population in terms of the relative importance of those attributes contained in $V_{jq}$ hence($\beta$, not $\beta_{jq}$). Clearly the particular definition of the dimension of $V_{jq}$ will depend largely on the population studied, the ability to segment the sampled population in such away that each segment satisfies homogeneity of utility and the extent to which one can measure known or assumed attributes yielding representative utility (Louviere et al., 2000).

The systematic component is assumed to be that part of utility contributed by attributes that can be observed by the analyst, while the random component is the utility contributed by attributes unobserved by the analyst. This does not mean that individuals maximise utility in a random manner; to the contrary, individuals can be deterministic utility maximisers. Randomness arises because analyst can not “peep into the head” of each individual and fully observe the set of influencing factors and the
complete decision calculus; which in turn implies that the analyst can only explain choice up to a probability of event selection (Louviere et al., 2000).

2.6.1. Formulation of the Utility model

In developing the general structure of an individual choice model, the key assumption is that individual \( q \) will choose alternative \( j \), if and only if (iff):

\[
U_{jq} > U_{iq}, \forall i \neq j \in A. \tag{2.2}
\]

Thus, from equations (i) and (ii), alternative \( j \) is chosen iff:

\[
(V_{jq} + \varepsilon_{jq}) > (V_{iq} + \varepsilon_{iq}) \tag{2.3}
\]

Rearranging to place the observables and unobservables together yields:

\[
(V_{jq} - V_{iq}) > (\varepsilon_{iq} - \varepsilon_{jq}) \tag{2.4}
\]

The analyst does not observe \((\varepsilon_{iq} - \varepsilon_{jq})\), hence can not determine exactly if \((V_{jq} - V_{iq}) > (\varepsilon_{iq} - \varepsilon_{jq})\). One can only make statements about choice outcomes up to a probability of occurrence. Thus, the analyst has to calculate the probability that \((\varepsilon_{iq} - \varepsilon_{jq})\) will be less than \((V_{jq} - V_{iq})\). This leads to the following equation:

\[
P(x_j / x_q, A) = P_{jq} = P[0 < (\varepsilon(X, x_i) - \varepsilon(X, x_j)) < (V(x_j) - V(x_i))] \text{ for all } j \neq i. \tag{2.5}
\]

interpreted as the probability that a randomly drawn individual from the sampled population, who can be described by attributes \( X \) and choice set \( A \), will choose \( x_j \) equals the probability that the difference between the random utility of alternatives \( i \) and \( j \) is less than the difference between the systematic utility levels of alternatives \( j \) and \( i \) for all alternatives in the choice set. The analyst does not know the actual distribution of \( \varepsilon \) across the population, but assumes that it is related to the choice probability according to a distribution yet to be defined. Thus equation (v) is the Random Utility model (Louviere et al., 2000).

An example of a destination choice is shown in the figure 2.7 below, where a trip will be made if the net-utility \( V_j \) is positive: \((N_j - Z_j) - N_i > 0\). The alternative \( c \) is chosen that maximizes the net-utility \( V_c = \max(V_{jn}) \).
Also from economic choice theory, McFadden (1986) in his quotation, *An object can have no value unless it has utility. No one will give any thing from an article unless it yields him satisfaction. Doubtless people are sometimes foolish, and buy things, as children do, to please a moment’s fancy; but at least they think at the moment that there is a wish to be gratified, utility was viewed as a virtual synonym for choice behaviour subject to vagaries of whim and perception until the mathematization of consumer theory.

2.6.2. Discrete choice models

Discrete choice exists when individuals have to select an option from a finite set of alternatives. In general, discrete choice models postulate that:

*The probability of individuals choosing a given option is a function of their socioeconomic characteristics and the relative attractiveness of the option* (Ortúzar and Willumsen, 1994).

According to Ortúzar and Willumsen (1994), the attractiveness of the alternatives is represented by the concept of utility which is defined as what the individual seeks to maximize. Alternatives do not produce utility but it is derived from their characteristics and those of the individual; for example the observable utility is usually defined as a linear combination of variables such as

\[
V_{\text{car}} = 0.25 - 1.2IVT - 2.5ACC - 0.3C/I + 1.1NCar
\]  

(2.6)

where each variable represents an attribute of the option or of the traveller. The relative influence of each attribute, in terms of contribution to the overall satisfaction produced by the alternative is given by its coefficient; for example, a unit change on access time (ACC) has approximately twice the impact of a change on in-vehicle travel time (IVT) and more than seven times the impact of a unit change on the variable cost /Income(C/I). The variables can also represent characteristics of the Individual such as one would expect that an individual belonging to a household with a large number of cars would be more likely to choose the car option than another belonging to a family with just one car. The alternative specific constant 0.25 is normally interpreted as representing the net influence of all un observed or not explicitly included characteristics of the individual or the option in its utility function such elements as comfort and convenience which are not easy to measure or observe.

To predict if an alternative will be chosen, according to the model, the value of its utility must be contrasted with those of alternative options and transformed into a probability value between 0 and 1. However, discrete choice models can not be calibrated using standard curve-fitting techniques, such
as least squares, because their dependent variable \( P_i \) is an unobserved probability ( which are either 0 or 1) and the observations are the individual choices ( which are either 0 or 1).

### 2.6.2.1. The Multinomial Logit (MNL) Model

This is the simplest and most popular practical discrete choice model and can only be generated assuming that the random residuals are distributed identically and independent such that:

\[
P_{iq} = \frac{\exp \left( \beta V_{iq} \right)}{\sum_{A_j \in A (q)} \exp \left( \beta V_{jq} \right)} \tag{2.7}
\]

Where the utility functions usually have the linearity in the parameters form \( V_{jq} = \sum \beta_{jk} x_{jq} \) and the parameter \( \beta \) (which is taken as one in practice).

If for all the individuals \( q \) that have available a given alternative \( A_j \) one of the values of \( x \) is defined as equal to one, the coefficient \( \beta \) corresponding to that variable is interpreted as an Alternative Specific Constant. Although one may specify a constant for every option, it is not possible to estimate their \( N \) parameters individually due to the way the model works. For this reason one is taken as a reference (fixing its value to zero without loss of generality) and the remaining \((N - 1)\) values obtained in the estimation process, are interpreted as relative to the reference. The rest of the variables \( x \) may be of one of two kinds:

- generic, if they appear in the utility function of every alternative and their coefficients can be assumed identical i.e. \( \beta_{jk} \) may be replaced by \( \beta_k \):
- specific, if the assumption of equal coefficients \( \beta_{jk} \) is not sustainable, atypical example occurring when the \( k^{th} \) variable only appears in \( V_j \).

It must be noted that the most general case considers specific variables only; the generic ones impose on it an equality of coefficients.

Consider a binary logit model:

\[
P_1 = \frac{\exp(V_1)}{\exp(V_1) + \exp(V_2)} = \frac{1}{1 + \exp(V_2 - V_1)} \tag{2.8}
\]

Where the observable utilities are postulated as linear functions of two generic variables \( X_1 \) and \( X_2 \), and two constants (with coefficients \( \beta_3 \) and \( \beta_4 \)) as follows:

\[
V_1 = \beta_1 x_{11} + \beta_2 x_{12} + \beta_3; \quad V_2 = \beta_1 x_{21} + \beta_2 x_{22} + \beta_4 \tag{2.9}
\]

As can be seen from the model expression, the relevant factor is the difference between both utilities:

\[
V_1 - V_2 = \beta_1 (x_{21} - x_{11}) + \beta_2 (x_{22} - x_{12}) + (\beta_4 - \beta_3) \tag{2.10}
\]
This allows deducing the following conclusions:

- It is not possible to estimate both \( \beta_3 \) and \( \beta_4 \), only their difference; for this reason there is no loss of generality if one is taken as 0 and the other estimated relative to it (this of course applies to any number of alternatives).
- If either \( X_{ij} \) and \( X_{2j} \) have the same value for both options (as for the case of variables representing individual attributes, such as Income, age, sex or number of cars in the household), a generic coefficient cannot be estimated as it would always multiply a Zero value. This also applies to level-of-service variables which happen to share a common value for two or more options for example public transport fares in a regulated market.

### 2.6.2.2. Properties of MNL Model

An important class of random utility models is that generated by utility functions with independent and identically distributed (IID) residuals \( \varepsilon \). The residuals are random and independent across alternatives and are identically distributed also called Gumbel distribution. Multinomial logit models can be generated assuming the random residuals are independent and randomly distributed among alternatives (Louviere et al., 2000).

The model satisfies the axiom of independence of irrelevant alternatives (IIA) which can be stated as: Where any two alternatives have a non-zero probability of being chosen, the ratio of one probability over the other is unaffected by the presence or absence of any additional alternative in the choice set (Ortúzar and Willumsen, 1994). For the MNL case it can be seen that the ratio:

\[
\frac{P_j}{P_i} = \exp \left\{ \beta (V_j - V_i) \right\}
\]  

is indeed a constant independent of the rest of the options.

### 2.6.3. Review of Statistical Estimation of Random Utility Models

In estimation of models from random samples, the Maximum likelihood (ML) method is normally used to estimate the coefficients \( \beta_k \). Maximum likelihood estimation is probably the most general and straightforward procedure for finding estimators. Stated simply, a maximum likelihood estimator is the value of the parameters for which the observed sample is most likely to have occurred. ML estimators have the following properties: they are consistent; they are asymptotically normal; they are asymptotically efficient (Ben-Akiva and Lerman, 1985). ML is based on the idea that although a sample could originate from several populations, a particular sample has a higher probability of having been drawn from a certain population than from others. Therefore the ML estimates are the set of parameters which will generate the observed sample most often. This idea can be illustrated by considering a sample of \( n \) observations of a given variable \( Z = \{Z_1, \ldots, Z_n\} \) drawn from a population characterized by a parameter \( \theta \) (Mean variance, etc.). As \( Z \) is a random variable it has associated a density function \( f(Z/\theta) \) which depends on the values of \( \theta \). The values of \( Z \) in the sample being independent, the joint density function can be written as

\[
f(Z_1, Z_2, Z_n/\theta) = f(Z_1/\theta)f(Z_2/\theta)\cdots f(Z_n/\theta)
\]  

\( (2.12) \)
and the usual statistical interpretation of this function is with \( Z \) as variables and \( \theta \) fixed. Inverting the process, the previous equation can be interpreted as a likelihood function \( L(\theta) \); if one maximizes it with respect to \( \theta \), the result is called Maximum likelihood estimate because it corresponds to the parameter value which has the greatest probability of having generated the observed sample.

Estimation of model parameters \( \theta(\beta) \) is less biased in large enough samples and may be more biased in small samples. Normally samples of 500 to 1000 samples observations are more than adequate to give better estimations (Louviere et al., 2000).

2.6.3.1. Estimation of Utility Model Parameters

An estimate of \( \beta_{jk} \) can be interpreted as an estimate of the weight of the attribute \( k \) in the utility expression \( V_j \) of alternative \( j \). Given estimates of the \( \beta_s \), an estimate of \( V_{jq} \) can be calculated by taking the \( \beta_s \) and the \( X_s \) for individual \( q \) and alternative \( j \) and using equation \( V_{jq} = \sum \beta_{jk} X_{jq} \). The resulting \( V_{jq} \) can be interpreted as an estimate of the relative utility \( U_{jq} \) of alternative \( j \) to individual \( q \). Analysts can evaluate generic and alternative-specific specifications for an attribute that exists in more than one utility expression across the choice set (Louviere et al., 2000).

2.6.3.2. Statistical Significance of Utility Model Parameters

In general the well understood properties of the Maximum Likelihood (ML) method for well-behaved likelihood functions allow, as in multiple regression, a number of statistical tests which are of a major importance. For this reason, it is possible to test whether \( \theta_k \) is significantly different from zero and thus a choice model analogue to the types of statistical tests performed on ordinary least squares regression weights for example t-tests is required. Only the Maximum Likelihood Estimation method provides such capability if the asymptotic property of the method is satisfied; that is the tests are valid only in very large samples. The maximum likelihood procedure permits to calculate asymptotic standard errors for the \( \beta_s \) in the MNL model and use these to test the statistical significance of individual \( \beta_s \) using the asymptotic t-tests.

Typically mean utility parameters which have sufficiently small standard errors (variations around the mean) are required so that the mean estimate is a good representation of the influence of the particular attribute in explaining the level of relative utility associated with each alternative.

The ratio of the mean parameter to its standard error is the **t-value** (desirably 1.96 or higher so that one can have 95% or greater confidence that the mean is statistically significantly from zero). According to Louviere et al. (2000) t-values as low as 1.6 are often accepted although this is stretching the usefulness of a mean estimate. A number of specification improvements are suggested such as segmentation, to enable an attribute to have a different mean and smaller standard error with in each segment compared to the whole sample or more aggregate segments. Many possible reasons why an attribute may not be statistically significant are given and these include (Louviere et al., 2000):

- Presence of outliers on some observations (very small or very large values of an attribute which lie outside the range of most of the observations);
- Missing or erroneous data (often set to zero, blank, 999 or -999);
• Non-normality in the attributes distribution which limits the usefulness of t-statistics in establishing levels of statistical significance;

• And the fact that the attribute is simply not important influence of the choice under study.

More informal tests such as examining the sign of the estimated coefficient to judge whether it conforms to a priori notions or theory. Thus it is worth noting that rejection of a variable with a proper sign crucially depends on its importance (Ortúzar and Willumsen, 1994). For example the set of available explanatory variables can be usefully divided into two classes:

• Highly relevant or policy variables which have either a solid theoretical backing and/or which are crucial to model forecasting;

• Other explanatory variables, which are either not crucial for policy evaluation (e.g. gender), or for which there are no theoretical reasons to justify or reject their inclusion.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Policy</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct sign</td>
<td>Significant</td>
<td>Include</td>
</tr>
<tr>
<td></td>
<td>Not significant</td>
<td>Include</td>
</tr>
<tr>
<td>Wrong sign</td>
<td>Significant</td>
<td>Big problem</td>
</tr>
<tr>
<td></td>
<td>Not significant</td>
<td>Problem</td>
</tr>
</tbody>
</table>

Source: (Ortúzar and Willumsen, 1994)

Current practice recommends including a relevant variable with a correct sign even if it fails any significance test. The reason is that the estimated coefficient is the best approximation available for its real value; the lack of significance may just be caused by lack of enough data (Ortúzar and Willumsen, 1994).

Variables of the other class with a wrong sign are always rejected; however, as variables of the policy type must be included at almost any cost, current practice dictates in their case model re-estimation, fixing their values to one obtained in a similar study elsewhere. This will be an easy task if the variable is also non-significant, but might be very difficult otherwise as the fixed value will tend to produce important changes in the rest of the model coefficients (Ortúzar and Willumsen, 1994).

2.6.3.3. Overall goodness-of-fit tests

To determine how well the basic MNL model fits a given set of data, one would like to compare the predicted dependent variable with the observed dependent variable relative to some useful criterion. Louviere et al. (2000) provide a test that allows one to evaluate predicted probabilities against a vector of observed discrete-choices. It can be used to evaluate the out of sample fit of any MNL model by taking repeated samples of the data.

1. The likelihood ratio test

The log likelihood function evaluated at the mean of the estimated utility parameters is a useful criterion for assessing overall goodness-of-fit when the maximum likelihood estimation method is used to estimate the utility parameters of the MNL model. This function is used to test the contribution of particular (sub) sets of variables and the procedure is known as the likelihood ratio test (LR).
To test the significance of the MNL model in large samples, a generalized likelihood ratio test is used. The null hypothesis is that the probability $P_i$ of an individual choosing alternative $i$ is independent of the value of the parameters in the multinomial logit function. If this hypothesis is retained it is inferred that the utility parameters are zero and; that is, analogous to an overall F-test in ordinary least squares (OLS) regression, the null is that all $\beta$s in the MNL model equation are zero (except alternative-specific constants). Similar to the testing the significance of $R^2$ in OLS regression, the hypothesis of independence is almost always rejected for a specific model. Thus the usefulness of the likelihood ratio test is its ability to test if subsets of the $\beta$s are significant. The generalized likelihood ratio criterion has the following form:

$$L^* = \max L(\omega) / \max L(\Omega)$$  \hspace{1cm} (2.13)

Where $L^*$ is the likelihood ratio; $\max L(\omega)$ is the maximum of the likelihood function in which $M$ elements of the parameter space are constrained by the null hypothesis. In testing the significance of a set of $\beta$s in the MNL model, $L(\Omega)$ is the maximum with these $\beta$s set equal to zero (constrained) and $\max L(\omega)$ is the unconstrained maximum of the likelihood function. The likelihood function $L$ for the basic MNL choice model takes on values between zero and one because $L$ is the product of $Q$ probabilities, and thus the log likelihood function $L^*$ will always be negative (Ortúzar and Willumsen, 1994).

2. The Likelihood - Ratio ($\rho^2$) Index

The $\rho^2$ index is used to measure the goodness-of-fit of the MNL model, analogous to $R^2$ in ordinary regression and is given by the following equation:

$$\rho^2 = 1 - \left[ L^*(\beta) / L^*(0) \right]$$  \hspace{1cm} (2.14)

It is noted that $L^*(\beta)$ will be larger than $L^*(0)$, but in case of the MNL model, this implies a small negative number, such that $L^*(\beta) / L^*(0)$ must lie between zero and one. The smaller this ratio, the better the statistical fit of the model (i.e., the greater the explanatory power of the attributes ($X$s) relative to an aggregate, constant share prediction); and hence, the larger is the quantity 1 minus this ratio. Thus, $\rho^2$ (rho-squared) is used as a type of pseudo-$R^2$ to measure the goodness-of-fit of the MNL model. Values of $\rho^2$ between 0.2 and 0.4 are considered to be indicative of extremely good model fits. Simulations by Domencich and McFadden (1975) equivalenced this range as from 0.7 to 0.9 for a linear function. Analysts should not expect to obtain $\rho^2$ values as high as the $R^2$’s commonly obtained in many stated choice ordinary least squares regression applications (Ortúzar and Willumsen, 1994).

2.6.4. Behavioural Outputs of Choice Models

The random utility model represented by the MNL function provides a very powerful way to assess the effects of a wide range of policies. Policies impact individuals to varying degrees, hence it is
important to be able to determine individual-specific effects prior to determination of market share effects. If an estimated model was carefully developed so that the systematic utility is well specified empirically, the model should be a very flexible, policy-sensitive tool (Louviere et al., 2000).

The types of policy outputs arising from choice models are similar to most statistical models. The models can be used to estimate the responsiveness of a population group to changes in levels of particular attributes (i.e., elasticities of particular choices with respect to certain attributes); to marginal rates of substitution between attributes (i.e. valuation), and to obtain individual and group estimates of the likelihood of choosing a particular activity, given the levels of the attributes offered as the significant choice discriminators (Louviere et al., 2000).

2.6.4.1. Elasticities of Choice

The appropriateness of various policies can be evaluated with the measures of responsiveness of market shares to changes in each attribute. Direct and cross elasticities can be estimated. A direct elasticity measures the percentage change in probability of choosing a particular alternative in the choice set with respect to a given percentage change in an attribute of the same alternative. A cross elasticity measures the percentage changes in the probability of choosing a particular alternative in the choice set with respect to a given percentage change in an attribute of a competing alternative.

The Direct point elasticity for the MNL model is given by the following equation:

\[ E_{x_{ikq}}^{piq} = \beta_{jk} X_{ikq} \left( 1 - P_{iq} \right) \]  

(2.15)

(Derived from the MNL equation and \( V_j = \sum_k \beta_{jk} X_{jkq} \)) interpreted as the elasticity of the probability of choosing alternative \( i \) for individual \( q \) with respect to marginal (small) change in the \( k^{th} \) variable which describes the utility of the \( i^{th} \) alternative for individual \( q \).

The cross point elasticity is evaluated similarly and given by the equation:

\[ E_{x_{ikq}}^{piq} = -\beta_{jk} X_{jkq} P_{jq} \]  

(2.16)

That gives % change in the probability of choosing alternative \( i \) with respect to a marginal change in the value of the \( k^{th} \) attribute of alternative \( j \) for individual \( q \).

2.6.4.2. Valuation of Attributes

Increasingly, discrete choice models are being used to derive estimates of the amount of money an individual is willing to pay (or willing to accept) to obtain some benefit (or avoid some cost) from a specific action. In a simple linear model where each attribute in a utility expression is associated with a single taste weight, the ratio of two utility parameters is an estimate of the willingness to pay (WTP) or Willingness to accept (WTA), holding all other potential influences constant. If one of the attributes is measured in monetary units, then the marginal rates of substitution arising from the ratio of two utility parameters is a financial indicator of WTP or WTA. Thus valuation implies the measurement of welfare implications of a specific policy (Louviere et al., 2000).
3. Study Area Description

3.1. Background of the Study Area

Dar es Salaam is the largest city in Tanzania. It is a coastal city located in the eastern part of the country. It is popularly believed that Dar es Salaam means the “Harbour of Peace” and it was established in the early 1860s, as a trading centre by Arab merchants. Later its roles and functions changed, and has since experienced significant growth since its foundation. Dar es Salaam was declared a township in 1920 and it was designated as a municipality in the British Colonial period in 1949. When Tanzania became independent in 1961, Dar es Salaam became a city and later it became the Capital of the United Republic of Tanzania. Although the Capital was moved to Dodoma in the 1970s, Dar es Salaam has remained and continuously served as the largest and most important commercial and administrative city in the country. It is an important centre for transport, business, and cultural activities. Looking at the urban growth pattern of the city, urbanization has extended significantly along the coastline and the major arterial roads: Bagamoyo; Morogoro; Nyerere and Kilwa Road, resulting into a mono-centric radial development pattern.

3.2. Physical Characteristics

3.2.1. Location

The City is located between latitudes 6.36 degrees and 7.0 degrees to the south of Equator and longitudes 39.0 and 33.33 to the east of Greenwich. It is bounded by the Indian Ocean on the east and by the Coast Region on the other sides. The Urbanised Area of Dar es Salaam is located on a coastal plain bounded by the Indian Ocean on the east and the Pugu hills to the west. Its location on the coast has a remarkable role on the economic activities of the country. It serves not only as a national port for export and import of commodity in the country but also serves the entire East African region.

Figure 3-1: Study Area Location
3.2.2. Administrative Boundaries

Dar es Salaam consists of administratively three Municipalities: Kinondoni, Ilala and Temeke Municipalities. The Municipality is administratively divided into wards and currently the city consists of 73 wards. The total surface area of Dar es Salaam City is 1,800 square kilometres, comprising of 1,393 square kilometers of land mass with eight offshore islands, which is about 0.19% of the entire Tanzania Mainland’s area.

Table 3-1: Distribution of the Total Land Area of Dar es Salaam City, by Municipality

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Total Land Mass Area (Square Kilometres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilala</td>
<td>210</td>
</tr>
<tr>
<td>Temeke</td>
<td>652</td>
</tr>
<tr>
<td>Kinondoni</td>
<td>531</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,393</strong></td>
</tr>
</tbody>
</table>

Source: (Dar es Salaam City Council, 2004)

3.2.3. Land Use

Land use is an essential element in understanding urban activities. The major characteristics of the existing land use pattern in Dar es Salaam are summarized as follow: In Dar es Salaam as a whole, there are still huge vacant and/or agricultural lands which occupy 78.3% of the total land area of the city; The built-up areas including residential, other urban use and industrial use occupy 17.4% of the total land area of the city; In the area within 10 km radius from the City Centre, the built-up area occupies more than 70% of the total land area; In the area from 10 km to 15 km radius, the built-up area occupies about 35% of the total land area. In the area beyond 15 km radius, the built-up area is located along the major arterial roads and forms a radial development pattern. Figure 3-2 below illustrates the existing land use pattern in Dar es Salaam. Table 3.2 below shows the land use area by category according to distance from the City Centre.

Table 3-2: Land Use Composition by Distance from the City Centre (CBD)

<table>
<thead>
<tr>
<th>Land Use Category</th>
<th>Within 5km (%)</th>
<th>5-10 km (%)</th>
<th>10-15km (%)</th>
<th>15-30km (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>48.2</td>
<td>55.9</td>
<td>26.8</td>
<td>5.5</td>
</tr>
<tr>
<td>Industry</td>
<td>15.4</td>
<td>4.7</td>
<td>2.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Other Urban Use</td>
<td>15.3</td>
<td>8.0</td>
<td>6.8</td>
<td>1.3</td>
</tr>
<tr>
<td>Military</td>
<td>1.7</td>
<td>0.2</td>
<td>0.8</td>
<td>0.2</td>
</tr>
<tr>
<td>River/Water</td>
<td>2.4</td>
<td>2.9</td>
<td>3.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Vacant/Agriculture</td>
<td>17.0</td>
<td>28.3</td>
<td>60.1</td>
<td>89.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
3.2.4. Road Network

The road development in Dar es Salaam has been still limited to major trunk road systems of national and regional level. The trunk road network is a radial arterial road network focusing on the central business district. The sections of this trunk road network, which consists predominately of one lane per direction, are highly congested and low operational speeds prevail during peak times i.e. 20 to 30 km/hr. Thus, proper management and maintenance of the network is vital for the economic growth of the city. According to the transport study conducted in 1995 by JICA, the major road network in Dar es Salaam was categorized into three types, namely trunk roads, regional roads, and district roads. The total length of the trunk roads in 1995 was 144.5 km, and that of regional roads was 314.0 km. A total of roads in other categories, including district roads, major and minor feeder roads were 691.1 km.

Based on the study report of (Logit, 2007) and the field experience of the Researcher, road ways are scarce and the road capacity is low. There are approximately 1140 km of roads where only 450 km are paved (39.5%). Sidewalks are in most cases inexistent and they are not paved in general. Also, the road system does not have the required density to develop proper urbanisation. According to Logit (2007). Normally a dense city would have a value superior than 5km of roads per square km, but for Dar es Salaam case, there is only 0.84 km of road way per square km. Also due to the bad conditions and Daladala downtown prohibition, only 265 road km is used by public Transportation.

3.3. Demographic Characteristics

3.3.1. Population

Dar es Salaam is one of the fastest growing cities in Sub Saharan Africa. The city has exhibited a strong population growth, from a population of only about 3,500 in 1867 to 128,742 in 1957 which further grew to 272,821 in 1967 and to 843,000 in 1978. The 1988 census established a population of 1.36 million persons. This had expanded to 2.49 million persons at time of the 2002 census, and an estimated 3.07 million persons by 2007: with an average annual 19 year growth rate of 4.4% per annum. The relatively high population growth rate is due to increased birth rates, immigration rates, and more significantly by transient population. In the City, Kinondoni Municipality has the largest population among the three municipalities. It had 1,083,913 habitants in 2002, which occupied 44% of the total population of Dar es Salaam. According to the average population growth rate, Kinondoni Municipality had the highest growth rate of 5.6% per annum during the period from 1978 to 1988, followed by Temeke Municipality with 4.5% per annum and Ilala Municipality with 3.8% per annum.

<table>
<thead>
<tr>
<th>Dar es Salaam Municipality</th>
<th>Population</th>
<th>Average Annual Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ilala</td>
<td>228,235</td>
<td>331,563</td>
</tr>
<tr>
<td>Temeke</td>
<td>258,581</td>
<td>401,786</td>
</tr>
<tr>
<td>Kinondoni</td>
<td>364,705</td>
<td>627,416</td>
</tr>
<tr>
<td>Total</td>
<td>851,522</td>
<td>1,360,365</td>
</tr>
</tbody>
</table>

Source: (JICA, 2007; Population and housing census[PHC], 2002)

3.3.2. Population Density

Based on the 2002 Population and Housing census report, the average population density in Dar es Salaam was about 15 persons/ha in 2002 and each municipality was: 21 persons/ha in Kinondoni Municipality, 18 persons/ha in Ilala Municipality and 10 persons/ha in Temeke Municipality. Large population growth is mainly in the areas of 5-15 km radius from the City Centre.

Figure 3-3: Population Density
3.3.3. Age Distribution

Based on the 2002 Population and Housing Census statistics, majority of the city’s population (65%) are aged between fifteen and sixty-four years which is in the working age. The young population below the age of fifteen years is 33% with few elderly people (only 2% are above 65 years), which implies that the life expectancy is low. This is also indicated by the pie chart figure 3-4 below.

![Age Distribution of Dar es Salaam Population](image)

Figure 3-4: Age Distribution of Dar es Salaam Population
Source: (Population and housing census[PHC], 2002)

3.3.4. Population Distribution by Gender

Table 3-4: Population Distribution by Gender

<table>
<thead>
<tr>
<th>Total Population</th>
<th>Number of Male</th>
<th>Number of Female</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>2,487,288</td>
<td>1,254,853</td>
<td>1,232,435</td>
<td>50.45</td>
</tr>
</tbody>
</table>

Source :(Population and housing census[PHC], 2002)

3.3.5. Fertility Rate

Fertility is on the decline as revealed by the falling Crude Birth Rates (CBR) and Total Fertility Rates (TFR) reflecting the rising age at first marriage and greater awareness of family planning. The current Crude Birth Rate stands at 40/1000 meaning that for each one thousand women there are forty births.

3.3.6. Death Rate

As per World Bank Century Study carried out in 2002, crude death rate is 14/1000. This means there are 14 deaths per thousand people.

3.4. Socio-Economic Characteristics

Based on the 2002 census statistics and World Bank Assessment Report, 2002, 70% of Dar es Salaam population is low income people. Poverty remains high despite the interventions which have been put in place to check on it.
3.4.1. Household Economy

The Household Survey 2000/2001 showed 7.5% of Dar es Salaam population as being unable to get adequate food (food poverty) and 17.6% unable to get basic needs (basic needs poverty). The table above shows marked improvements in efforts to alleviate poverty although the level is still high.

Table 3-5: Trend in Poverty Indicators for Dar es Salaam

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Poverty</td>
<td>13.6</td>
<td>7.5</td>
</tr>
<tr>
<td>Basic Needs Poverty</td>
<td>28.1</td>
<td>17.6</td>
</tr>
</tbody>
</table>

3.4.2. Employment

It is estimated that about 95% of City residents are working in the informal sector, while the remaining 5% are employed in the formal sector including the Government and Public Institutions. Based on statistics for 2002, unemployment in the City of Dar es Salaam was 46.5% while in other urban areas it was 25.5% and 18% in rural areas.

3.4.3. Income

Based on the 2002 Population statistics from the Bureau of Statistics, the GDP of Dar es Salaam was Tshs 1,459,013 which represented 16% of the national GDP of Tshs 8,618,071. The survey indicates GDP per capita for Dar es Salaam to be Tshs 584,086 with 35% of the population earning an average low income of Tshs 387,319 per annum (about Tshs 32,000 per month).

3.5. Modal Share

Despite the fact that walking and cycling facilities are poor and mainly non-existent in the city, non motorised transport has the highest modal share. The main mode of transport is the Non Motorised Transport and public transport with a percentage modal share of 45% and 43% respectively. The modal share of private car is 6%, and the remaining 6% is share for other modes.

3.6. Current Situation of Public Transport in Dar es Salaam

Public transport in Dar es Salaam City is generally poor and unsafe, lacking professionalism, efficiency, quality and safety for the 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. Public transport service is mainly dominated by small buses called Daladala, of which there are about 9,000 of these Daladala, with capacities ranging from 16 to 35 passengers. The actual fare level of the daladala’s is 250-350 Tsh, independent of the travel distance. Students have to pay only 50 Tsh. (Kanyama et al., 2004). Although the daladalas are by far the major public transport mode, the service offered is mainly poor and characterised by the following main problems as stated by (Kanyama et al., 2004):

1. Overloading of buses: Overloading and overcrowded buses particularly during peak hours, also characterised by reckless driving, route shortening, This overloading results in pick-pocketing,
impaired air circulation, bad smells, harassment of women and school children, sexual abuse and commuter worries about the spread of diseases.

2. **Travel time:** The majority of the commuters consider the travel time as long. For many commuters it takes less time to reach the city centre. The problem of long travel time is indicated by this interesting quote “in order to minimize travel time during the morning rush hour, some commuters who live in the middle of bus routes, especially those in a hurry to work, board buses going in the opposite direction so as to return with them to the desired destination. In this way, commuters are prepared to pay the fare two-fold in order to save waiting time” (Kanyama et al., 2004)

3. **Poor comfort level:** Many commuters consider daladala noisy and unhygienic. Also commuters remarked the poor treatment by conductors and the dangerous driving style of the daladala drivers.

4. **Air pollution:** the current transportation system is characterized by polluting vehicles particularly during peak hours dominated by traffic jams on most major roads which have a significant negative impact on the health of the city residents.

Therefore, given this current situation of public transport and based on the study of (Logit, 2007) which shows that in 30 years, Dar es Salaam will grow to 7.5 Million inhabitants and 3 million trips per day; one can conclude that if nothing is done, there will be chaos.

![Figure 3-5: Public Transport (Dala-dala) Situation in Dar es Salaam](image)

Source: (Kanyama et al., 2004)

### 3.7. The DART System

DART (Dar Rapid Transit) is the name of the proposed BRT system in Dar es Salaam. Dar Rapid Transit (DART) will be a high quality mass transport system operating on specialized infrastructure and offering affordable mobility, environmental improvements, and a better quality of life to the residents of Dar es Salaam city. Its long-term plan is to cover the whole city of Dar es Salaam by the year 2035. The DART system will be implemented in six phases and the first phase is planned to be implemented in 2009, with following corridors to be implemented every 4 years. Once the current plans are implemented, the total corridor length will be more than 130 kilometers. The DART mission
is to provide quality and affordable mass transport system for the residents of Dar es Salaam which will reduce emissions, enable poverty reduction, lead to sustainable economic growth, improve the standard of living and act as a pioneer of private and public investment partnership in the City. DART will achieve this by using: Modern, privately-managed buses with low emissions; Segregated bus lanes; Scheduled bus services; High capacity bus stations with a central platform; On level boarding; Privately-managed fare collection system; and average bus speeds over 22 km/hr (Logit, 2007). The DART Vision is “To have a modern public transport System at a reasonable cost to the users and yet profitable to the operators using quality, environmentally friendly, high capacity buses which meet international service standards that operate on exclusive lanes, reducing travel time” (Logit, 2007).

3.8. Institutional Organisation (DART Agency)

The DART Agency, a public agency, will be the regulatory authority that manages the DART System and ensures quality control. It will be responsible for overall management of the system, policy-setting, regulation, planning and controlling of operations and marketing. It is an executive agency created by the President’s Office – Public Service Management (PO-PSM). The DART Agency will report to Permanent Secretary-Prime Minister’s Office-Regional Administration and Local Government (PMO-RALG). As an executive agency, the DART Agency is a semi-autonomous legal entity that may enter into contracts in its own name. It can also borrow money, as well as acquire, hold or dispose movable and immovable property, pending approval of the Permanent Secretary. The Permanent Secretary (PMO-RALG) is responsible for the strategic management of the Agency, and for that purpose may give directions to the Chief Executive of the Agency “but with due regard to the need to uphold the Agency’s autonomy in the day-to-day management of its affairs” The Chief Executive of the Agency is appointed by the Minister on the advice of the Civil Service Commission (Logit, 2007).
3.9. **Summary**

This Chapter has described the study area from its historical background and went through to show its physical characteristics. The Socio-demographic and economic characteristics of the Study area have also been identified. Also the modal share of transport and the current situation of public transport and its related problems have been shown. Most importantly, the new development plans in the study area like introduction of the DART as a solution to the current urban transport problems have been clearly discussed and lastly the institutional frame work of the DART Agency which will be in charge was given. Having discussed the current situation of the study area, it is a turn to look at the methodology and data collection techniques used to obtain data from the study area in the next chapter.
4. Methodology and Materials

4.1. Introduction

Chapter 4 describes the methodology of the research used where a stated-preference approach is taken. A stated-preference approach is used to examine the perceptions and preferences of the potential commuters towards the proposed BRT in Dar es Salaam. With this method the first step is to identify the contributing factors related to the proposed BRT. Based on information of the contributing factors, the next step aims to examine the magnitude and spatial distribution of the proposed BRT System. Methodologies proposed in this study take advantages of stated choice modelling capability of mathematical and statistical techniques and the spatial analysis and visualisation capabilities of GIS. Figure 4.1 below shows the structure of the methodology followed and the methodological steps taken in this research.

![Methodological framework](image)

**Figure 4-1: Methodological framework**

4.2. Pre-field work Stage

In this stage three main tasks were accomplished that is to say the survey method was selected, set-up of experimental design and field survey design which were all done through intensive literature review. The methods taken and the data required were all identified in this stage through literature survey and also the potential sources of data and key contact persons were identified. These ultimately led to the development of the conceptual frame work and research design.

4.2.1. Selection of the Survey Method

To determine the perceptions and preferences of commuters towards the proposed BRT in Dar es Salaam, a stated choice survey technique was selected based on the main research objective and given the hypothetical situation of the problem under study. In SP studies people are offered hypothetical choices among different alternatives. Stated choice techniques are used to obtain information about the preferences of decision makers (Shen, 2005). A stated choice questionnaire contains a number of choice sets, which include two or more alternatives. The alternatives are combinations of attributes (like travel time, travel cost, comfort level) which differ on the values assigned to attributes. The respondents have to choose their desired option from the presented set of alternatives. To illustrate this principle, an example of one choice set in a stated choice research is given:
Table 4-1: Choice set example

<table>
<thead>
<tr>
<th>Mode Of Travel</th>
<th>Comfort level</th>
<th>Travel time (in-vehicle)</th>
<th>Price</th>
<th>Choose one</th>
</tr>
</thead>
<tbody>
<tr>
<td>Train</td>
<td>Seating guaranteed</td>
<td>30 minutes</td>
<td>$6</td>
<td>[ ]</td>
</tr>
<tr>
<td>Bus</td>
<td>Seating not guaranteed</td>
<td>40 minutes</td>
<td>$3</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Table 4.1 above is an easy example of a possible choice set. Respondents have to choose one of these two options which they like most. Do they prefer to take the cheaper, but slower option (Bus) without seat guarantee? Or do they like the more expensive option (Train), which is faster and guarantees a seat? The alternative labels in this example are the “Train” and the “Bus”, and the attributes are travel time, comfort level and price. Thus a stated choice questionnaire includes a number of this kind of questions (called choice sets).

4.2.2. Labeled and unlabeled experiments.

Experiments that use generic titles for the alternatives are called unlabeled experiments where as those in which a label is attached to each alternative such that each alternative contains extra information in addition to the attribute information are termed as labeled experiments (Hensher et al., 2005). In unlabeled experiments, respondents make choice solely on basis of the differences in attribute level values among the presented options (Louviere et al., 2000). In this study, un labeled experiment was used where the BRT was not mentioned in the questionnaire simply because the BRT was the only option and to avoid the bias that could be brought by the attached label ‘BRT’ in choice making.

4.2.3. Experimental Design Set-up

The design set-up of the choice experiment in this research was based on literature (Hensher et al., 2005; Louviere et al., 2000) and generating an experimental design followed different stages (refer to figure 2.2 in chapter two) discussed below.

4.2.3.1. Problem Definition Refinement

The choice experiment method was used in this study to examine the attitudes and preferences of commuters towards the proposed DART system and its attributes and to compare the preferences of the commuters to the proposed system attributes. This was carried out to identify the likelihood for commuters to use the DART service. In this study the important DART attributes needed to be identified based on the value put on each attribute during choice making by the interviewed commuters. This was all aimed at finding out whether the proposed DART service is socially and spatially desirable from potential users’ point of view in order to meet its intended goal and for its sustainability.

4.2.3.2. Identification of Alternatives

As part of the stimuli refinement, as suggested in literature (Hensher et al., 2005), one must identify each and every possible alternative to decision makers in order to meet the global utility maximising rule. However, in this study there were no possible alternative modes to the BRT option. Since all the existing public modes will be replaced completely by the BRT in the main roads based on the ground information from DART Agency, there will be no competitive modes and thus the BRT remains the only option. Therefore the study focused at the attributes of the BRT as the only alternative given its hypothetical condition and new policy in the study area.
4.2.3.3. Identification of attributes, attribute levels and level values

In identifying and deciding on the list of attributes and their levels to be used in this research the following considerations were taken important:

The more attributes covered in the choice experiment, the better the estimation of the systematic utility, however, a higher number of attributes means a longer questionnaire that results fatigue to respondents (Louviere et al., 2000). This is because a higher number of attributes requires a higher number of choice sets. Since a respondent can only answer a limited number of choice sets, the number of attributes and attribute levels should be kept small (Louviere et al., 2000).

Another reason for keeping the number of attributes small is that the task complexity for the respondent increases by the number of attributes and this task complexity lead to preference instability (Louviere et al., 2000; Shen, 2005). The consequence of this instability is that less accurate results will be obtained.

On the other hand, the attributes included in the research should cover all the main factors on which choice makers make a decision and if this is not the case, then this will result in less valid stated choice data (Shen, 2005). Literature suggests organizing a pilot survey to examine whether the number of attributes in the questionnaire is appropriate.

The more the levels of an attribute, the better the analyst’s ability to detect and understand complex utility relationships, however three attribute levels is enough to provide knowledge of a good approximation of the true underlying utility function (Hensher et al., 2005).

To identify the extreme ranges of the attribute level values, experiences of the decision makers related to those attributes in the experiment should be examined. The analyst may use experiences from secondary data search combined with focus groups to derive the extremes of the attribute-level values. However, analysts should consider using values outside of the identified range rather than the observed level values, but should be done with care (Hensher et al., 2005)

A. Criteria for Selecting Attributes.

To decide on which attributes and attribute level to be taken into the research, several criteria were set. Thus the following criteria were established for selecting the attributes:

1. Majority of the commuters have to regard the value of the attribute important. In other words: if they consider the attribute level value when choosing whether to use the bus for a trip or not to use the bus. This is somewhat arbitrary, but literature search and discussion with local staff contributed to clarify the attributes which people value mostly when considering a transport alternative.

2. It should be possible to influence and vary the attributes. Otherwise the commuters’ valuation of the attributes is not relevant to determine whether certain changes in the operational characteristics are of benefit.
B. Criteria for Setting up Attribute Levels

1. A relative large range of attribute levels will result in better statistical efficiency (Louviere et al., 2000). However, the level values should be realistic for the study object and acceptable to the respondents (Shen, 2005). In practice this means that the maximum and minimum level values for the attributes should be set to those values that are still acceptable to the respondent and still realistic for the proposed DART system.

2. Louviere et al. (2000) suggests avoiding unbalanced designs, because unbalanced designs will lead to different statistical power between attributes. Unbalanced designs are defined as designs for which attributes have a different number of levels, which levels are not multiples of each other. For example a design with numbers of attribute levels of 3 and 4 is unbalanced. A design with attributes having 3 and 6 levels is balanced, because 6 is a multiple of 3. Therefore for this research it means that the design should be balanced.

3. The middle level value of an attribute should be about the same as the expected DART value on a certain attribute. While setting extreme ranges, one of the level values should be higher than the proposed DART value and the other level value should be lower. Reason for this is that this research can accurately show the effects of both an increase and a decrease in the DART attribute level value.

C. Selected Attributes

Therefore, the final decision on the attributes and levels taken in the choice experiment was based on the considerations and criteria stated above, that is to say, on literature, on discussion with the local staff and importantly available financial and time resources.

The following four attributes were taken: Walking time to bus stop; In-vehicle travel time; Travel fare and Comfort level

**Travel Fare (one-way):** Travel fare is one of the primary attributes in this study. DART will operate according to a flat fare system and thus respondents were presented the same travel fare. According to the DART Investors Document (2007) the travel costs for the BRT one way is Tsh 500 and this was the fare considered in this research. The extreme fare values used were 300 Tsh. and 700 Tsh. This was determined after some discussion with DART Agency Staff and the interviewers, also which was later emphasized by the pilot survey.

<table>
<thead>
<tr>
<th>Travel fare attributes level values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>High</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Travel fare</th>
<th>Tsh = Tanzanian Shillings (1 US dollar = 1200 Tsh as of sept. 2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>300 Tsh</td>
</tr>
<tr>
<td>Medium</td>
<td>500 Tsh</td>
</tr>
<tr>
<td>High</td>
<td>700 Tsh</td>
</tr>
</tbody>
</table>
**In-Vehicle Travel Time (one-way):** The in-vehicle travel time is defined as the time that the commuter spends in the DART-vehicle to reach its destination. Based on the commercial speed, travel time is one of the main attributes of a transport system and is influenced by many factors as discussed in literature. Hence it was important to know how commuters value this attribute.

Given the fact that the CBD is the main trip attractor (Logit, 2007), it is not realistic to show same travel time to people living nearby the city centre as to people living in the outskirts. For this reason the travel time considered in the choice experiment varied based on the radial distance from the CBD (further discussed in section 4.2.4.2). Respondents living in wards far away from the CBD were presented BRT attribute choice options with substantial higher travel times than those living only a few kilometres from the CBD. Generally the medium level of travel time was obtained by the ratio of the distance to CBD from an origin to the expected trunk speed of 23 km/h. The amount of variation among the different attribute level values depended on the estimated travel time. The higher was the estimated travel time, the higher was the absolute difference among the attribute level values. However, the difference in terms of percentage is about the same: 30-40%, rounded to the nearest 5 minutes. Therefore, the used set of travel time is a good middle course between realism in travel times and a large enough interval for statistical efficient results.

**Table 4-3: In-vehicle travel time attribute level values**

<table>
<thead>
<tr>
<th>Low</th>
<th>0-5 km</th>
<th>5-10 km</th>
<th>10-15 km</th>
<th>&gt;15 km</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 min</td>
<td>15 min</td>
<td>25 min</td>
<td>40 min</td>
</tr>
<tr>
<td>Medium</td>
<td>15 min</td>
<td>25 min</td>
<td>40 min</td>
<td>60 min</td>
</tr>
<tr>
<td>High</td>
<td>20 min</td>
<td>35 min</td>
<td>55 min</td>
<td>80 min</td>
</tr>
</tbody>
</table>

**Walking time to bus stop:** It is the walking time it takes a respondent to reach the nearest BRT trunk stop from his home location. Together with the in-vehicle travel time valuation, this is an important variable for determining whether the number of bus stops should be increased or decreased. Also by determining the value of this attribute one can conclude whether it would be better to increase or decrease the number of feeder routes. Access walk time was determined based on the Dart reports which showed that each BRT stop will serve a 500m buffer. With help of this information and assuming a walking speed of 4km per hour (Amer et al., 2007), the attribute level values were set.

**Table 4-4: Walking time to bus stop attribute level values**

<table>
<thead>
<tr>
<th>Walk Time BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
</tr>
<tr>
<td>Medium</td>
</tr>
<tr>
<td>High</td>
</tr>
</tbody>
</table>

**Comfort level:** The fourth attribute was the comfort level during trip. Comfort level was put into the research because reports indicated that people value comfort highly (Kanyama et al., 2004). Also it was interesting to know how much people would like to pay for more comfort, thus it would be possible to advise about the bus design. Also for this attribute, three different level values were defined, as shown in table 4.5 below.
Table 4-5: Comfort level attribute values

<table>
<thead>
<tr>
<th>Comfort level</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overcrowded standing</td>
<td>Comfortable standing</td>
<td>Comfortable seating</td>
<td></td>
</tr>
</tbody>
</table>

Because the comfort level values are subjective to interpretation by the respondent, the level values should be clearly defined (Hensher et al., 2005; Shen, 2005). In this way the choice sets used were presented to the respondents in form of combined verbal and picture visualisations to limit interpretation differences (Adamowicz et al., 1998; Rastogi, 2000). More to that, the interviewers had to give an explanation of the values so that the interpretation bias is minimized. Thus the following explanations were used to clarify the definitions of comfort:

- **Comfortable seating** means that a commuter can sit during the complete journey.
- **Comfortable standing** means that the commuter can only stand during the trip. The standing conditions are comfortable, if the commuter can easily move his arms and legs, and can easily leave the bus without the need to ask other people to move.
- **Overcrowded standing** means also that the commuter has no seat available during the trip. However, in this case the standing conditions are worse than the comfortable standing level. Walking through the bus is almost impossible, because of the high number of people standing.

Thus, the respondent can roughly make a comparison with the standing comfort of an overcrowded daladala (current public transport in Dar es Salaam).

### 4.2.3.4. Experimental Design Considerations

Having identified the attributes and the number of attribute levels and their values, it was then a turn to decide on the design to be used. Literature gives different design classes, however in this study; the full factorial design was used. But before going to the design, it was necessary to look at the attribute coding.

**Attribute Coding:** Based on literature, a coding format was created to represent the possible combinations of attribute alternatives. This coding system assigned a unique number to each attribute level. An orthogonal coding system which uses values for codes which, when summed over any given column (not row), equals zero was used. To achieve this effect, an attribute was coded such that when a positive value is assigned one level, the second level was assigned a negative same value. This could only work in case of even number of levels. In case of odd number of attributes like in this particular research, the median value was assigned the value zero (Hensher et al., 2005). Therefore, since there were only three level attributes in this study, there were assigned values -1, 0, and 1. As suggested in literature, only odd numbers in such coding was used.

**Full Factorial Design:** This is a design in which all possible treatment combinations are enumerated. Given that there were four selected attributes with three levels each and only one alternative (BRT), the full factorial design was given by $L^{M*4}$ (labeled experiment) where L is the number of attribute levels, M is the number of alternatives and A is the number of attributes. However, since the unlabeled choice experiment was used in this study, the full factorial design was given by $L^4 = 3^4 = 81$. Thus, the full factorial design resulted to 81 different treatment combinations of attributes. In other words, 81 different choice options were created with the selected attributes and levels. However,
presenting decision makers with 81 choice sets may place a significant level of cognitive burden to respondents with a likely result of a decrease in response rates and/or response reliability (Louviere et al., 2000). More so, it could not be possible to include all of these choice sets in the questionnaire, simply because the questionnaire would be too much time-consuming for respondents and impractical. Thus, other strategies were thought of to reduce the number of choice sets and these were: reducing the number of attribute levels or reducing the size of experimental design. Reducing the number of attribute levels would dramatically reduce the design size; however, such a reduction comes at a cost of loosing the amount of information the design obtains in terms of observations gained. Hence, reducing the size of experimental design using a fractional factorial design was adopted.

**Fractional Factorial Design:** A fractional factorial design consists of a subset of the choice sets from the full factorial design (Louviere et al., 2000). To choose which treatment combinations (choice sets) to use, it was possible to select randomly a number of treatment combinations from the total number of 81 treatment combinations without replacement. However, random selection was likely to produce statistically inefficient design (Hensher et al., 2005). Thus, scientific method was adopted to produce statistically efficient fractional factorial design by generating an orthogonal design using a Statistical software SPSS. ‘An orthogonal design is a design in which all attributes are required to be statistically independent of one another that is to say having zero correlations between attributes’

**4.2.3.5. Generating Experimental Design**

In order to obtain a workable experimental design, the researcher used SPSS software to generate an orthogonal design. Before generating the design, it was decided to use the main effects only design where the attributes were named such that each design column that will be generated would be assigned to a specific attribute. ‘A main effect is defined as the direct independent effect of each attribute upon the response variable, choice i.e. it is the difference in the means of each level of an attribute and the overall or grand mean’ (Hensher et al., 2005)

In order to generate designs in SPSS, it was required to code the attribute levels using orthogonal codes so as to allocate the attributes to design columns. Orthogonal coding was desirable due to its property of allowing the analyst to observe the design columns for the interaction effects. To generate the interaction columns of a design, the analyst simply multiplies the appropriate main effects columns together. ‘An interaction effect is an effect upon a response variable, choice, obtained by combining two or more attributes which would not have been observed had each of the attributes been estimated separately’ (Hensher et al., 2005).

From the SPSS, a main effects only design of 25 treatment combinations was generated. This was too many and could be impractical, thus to produce the smallest design possible in SPSS it was specified to generate 18 number of cases. However, the design generated by SPSS consisted of too many non-useful choice alternatives. Hence, the questionnaire design was initially created by SPSS but later adjusted manually where 9 choice sets were obtained and taken in this study which has less task complexity to respondents and still acceptable to produce statistically efficient results based on literature. However, creating a design manually could lead to loss of statistical information (Louviere et al., 2000).
4.2.3.6. Generation of Choice sets

A choice set represents the machinery by which researchers gather information on the choices made by the sampled decision makers given the alternatives’ attributes and attribute levels as determined through an experimental design. Although, the generated experimental design expressed in a coded structure in the previous section was useful, some transformation was required to make the design ready for field survey. It was required to attach the relevant attribute level value to the design. Microsoft excel was used to replace the numerical coding with the attribute level values already decided upon. Thus taking the attribute level values and allocating them as discussed it was possible to generate choice sets to be shown to the sampled individuals. As already pointed out in the previous section, 9 treatment combinations of BRT attributes were created. By changing the attribute levels observed between the rows, the experimental design forces each treatment combination to act as a separate and independent choice set. The next step was to re-arrange each of the 9 treatment combinations into a workable choice set.

4.2.3.7. Randomizing Choice sets

In this step, it was necessary to re-arrange each treatment combination into a workable choice set that not only provided information on the attribute levels of the various options, but also allowed the decision maker some mechanism to make choice between the presented alternatives. The generated choice sets were randomized and grouped together using an excel sheet random generator which resulted into 9 pair-wise choice sets. However, some choices between two realistic alternatives were not useful, because it was already in advance known which of both alternatives would be chosen. This led to re-arranging of the attributes based on the following considerations:

- There should exist trade-off between two attribute alternate options (treatment combinations).
- The different attribute levels should appear as equal as possible in the questionnaire. In this way the statistical efficiency for estimating utility for each of the attribute levels will improve.
- The attributes in the choice sets should have a trade-off.

A pilot survey was held later to determine whether the trade-offs were reasonable.

4.2.3.8. Presentation of Choice sets

The attribute levels in the choice experiment were well defined to carry the same meaning to all decision makers surveyed. Abstract or ill-defined attribute levels might have been ambiguously interpreted by decision makers that would have added to the variability in choice without adding to the explanatory ability of the Researcher particularly for the qualitatively defined attributes. Also given the low literacy level of most people in the study area, it was necessary to use a presentation format that could be interpreted easily and homogeneously by all respondents. Hence the above reasons are key factors that led to presenting choice sets in picture format. Also based on his statement (Hensher et al., 2005) “A picture is worth a thousand words”, the attribute levels were presented in combined verbal and picture format to respondents so as to be perceived homogeneously which has an effect on better utility estimations. This statement was a key factor especially for the qualitative attributes like comfort where different interpretations from respondents were possible for the comfort attribute levels.

More to that from their study, Louviere, Anderson, Swait and Gray-Lee (1995) compared Stated Choice models estimated from experiments in which the attributes of alternatives were described purely verbally and the same attributes that could be visually described and found out that the scale of the utilities for the verbally described attributes differed significantly from the scale of the utilities for
the same attributes visually described. This is because Subjects in the visual experiment could integrate the image directly and evaluate it with respect to the other attribute. For the verbal descriptions, therefore, induced more unreliability in the choices because of the need to read and form images, and insofar as different individuals perceive the images or interpret the words differently, variability in choice was to be expected. The whole set of 9 choice sets presented to the individual respondents in one location of the study area is shown in appendix B. Figure 4-3 shows an example of one of the 9 choice sets used in the Stated Preference survey.

**Figure 4-2: Example choice set**

### 4.2.4. Field Survey Design

Once the choice sets were generated, it was then time to construct the survey. This step involved development of Survey questionnaire format, data collection technique, sampling strategy and determining the sample size.

#### 4.2.4.1. Survey Questionnaire

The survey questionnaire was opened with a brief introductory statement that was explaining the purpose of the field survey and its benefits to the entire city population. This statement was important as it clarified how important was the study and thus the respondents had to put value in filling the questionnaire. The survey questionnaire used was composed of three main parts: Part A was strictly stated choice questions; Part B was made to collect individual travel information and part C was meant to collect socio-economic and demographic information.

The experiences by (Hensher et al., 2005; Rastogi and Rao, 2002) showed that stated choice questions should be short with clear information and minimum writing requirement. The experiment should be
orthogonal, with options arranged in paired choice sets. Hence this was followed in formulation of the choice questionnaire. The stated choice part was put first in order to answered by the respondents while they were still fresh since it needed more thinking and given its high importance as the main heart of the whole research. The collected travel information was used to give an overview of the travel characteristics of the sampled population while the socio-economic and demographic information was relevant in this study as it was used to tell the nature of the sampled population in relation to the entire city population, and also as some of variables could be entered into the stated choice model. The socio-economic questions were placed at the end of the questionnaire since they comprised of sensitive questions like income and property ownership that would have disrupted the survey had these questions appeared at the beginning. The survey questionnaire included other information like interviewer names, Area of survey, date of interview, questionnaire identification number which assisted in good management of the survey process. The full detailed questionnaire is shown in appendix A. Figure 4.2 shows the set-up of the stated choice questionnaire used and the information collected in the survey. The arrows show the set-up order of main parts of the questionnaire.

![Survey Questionnaire Diagram](image)

*Figure 4-3: Main Parts of the Survey Questionnaire*

### 4.2.4.2. Data Collection Technique

It was decided to use a face-to-face personal interview method in collecting information from the sampled population. Although from his experience Rastogi and Rao (2002) found out that the delivered and mailed back method was more suitable than face-to-face method in collection of stated choice information, this could not be feasible in this particular study, given the time and budget constraint nature of this research since delivered and mailed back method requires more time and
ANALYSING COMMUTERS' ATTITUDES TOWARDS THE PROPOSED BUS RAPID TRANSIT SYSTEM

budget resources. Secondly, it was necessary and important to observe how the respondents made their choices where the interviewers had to express to the respondents that each scenario was to be treated as a separate hypothetical situation and should not be considered in conjunction with other choice sets. Otherwise, respondents may fail to treat each choice set independently as experience from literature shows (Hensher et al., 2005). Thus, personal interviews were relevant in this study so that the way the decision maker completed the survey could be monitored and strictly controlled.

4.2.4.3. Sample Size.
The sample size in stated choice surveys depends on the number of attributes and their levels, this is because a higher number of attributes requires a higher number of choice sets and thus a big sample required and secondly depends on the time and financial resources. However, because a respondent can only answer a limited number of choice sets, the number of attributes and attribute levels should be kept small. Also given that SP experiments are statistically efficient, in the sense that each interviewee produces not just one observation but several on the same choice context provides information about the variations in responses with in each individual. Normally samples of 500 to 1000 samples observations are more than adequate to give better estimations (Louviere et al., 2000). Based on the above discussions, the number of samples to be collected was limited to about 600-700 surveys and thus a total of 695 commuters were interviewed during the survey and only 684 well completed questionnaires were considered and taken for analysis.

4.2.4.4. Sampling Strategy Design
Ideally, the potential demand of the BRT should be measured in spatial units which are homogeneous within each spatial unit and heterogeneous between the units in regards to travel choice and factors. For this reason, it was needed to choose spatial divisions at a fine level of spatial granularity (Yao, 2007; Zuidegeest and Maarseveen, 2007a). The finest spatial division is a census block, however, Traffic Analysis Zones (TAZs) created by JICA in 1994 were used since TAZs are partitioned according to variables that are most pertinent to travel choices. Thus the stated preference survey was conducted in TAZs (also in this study named as residential zones) of wards where the BRT will pass.

Given the main objective of the research, the sampling strategy was based on the distance of the residential locations from the city centre (CBD), their locational distance from the BRT lines and the socio-economic characteristics of the city population. Personal interviews were conducted randomly to the individual commuters in their residential zones. The target population were individual commuters who travelled to the city centre (CBD) on regular basis. Given the fact that the CBD is the major trip attractor (Logit, 2007), an assumption was made that those commuters who travelled to the CBD were the potential users of the BRT. The sampled population were only the city residents and not visitors of the city. The questionnaire was set such that only information from the target group was collected.

The interviews were conducted to individuals during the evening time in their residential places when people were from work. This is because stated choice method needs more time for the respondent to understand the exercise and proper thinking before making a decision which could not have been possible at the bus stops. Conducting interview at bus stops or during commuting would have been more appropriate; however, this was not feasible and possible as the respondent is generally not at ease due to the tension of getting to work or going home during peak hours. Similarly if the interviews were to be conducted at the work place, then it would have required prior permission from the employer or
head of the office which is generally difficult to get. Even if permission is secured, the employee or respondent is so hard pressed with the work that he/she would reply as fast as possible. According to (Rastogi, 2002), the responses given in such situation, with lack of peace of mind, will always be less promising and unreliable, and would have affected the quality of the survey. Figure 4.4 below shows the spatial distribution of wards where samples were collected.

Given that the CBD was the main trip attractor, it was taken as reference in the creation of ring buffers based on the radial distance from the CBD to the residential locations of the people. This was made mainly to estimate the travel time and to detect its impact on travel attitude of commuters based on their locational distance from the CBD. It is not realistic to show same travel time to people living nearby the city centre as to people living in the city outskirts. For this reason the study area was divided into four ring buffers and each ring buffer was designed its own questionnaire where the in-vehicle travel time was varied based on the radial distance from the CBD while other variables remained the same in all the ring buffers. Respondents living in zones far away from the CBD were presented BRT attribute choice options with substantial higher travel times than those living only a few kilometres from the CBD. The four created ring buffers were: Zones with in 5km, 10 km, 15 km and more than 15km radial distance from the CBD. Based on the JICA progress report of 2007, it is indicated that almost 80% of city residential areas are with in 15 km radial distance from the CBD. Thus most samples were collected in residential zones of wards within that distance. The samples were collected randomly from residential zones within 2 km distance from the main BRT lines in wards.

Figure 4-4: Map of Surveyed Wards

Ring Buffers based on radial distance from CBD

Ring Buffer 1 = 0-5km
Ring Buffer 2 = 5-10 km
Ring Buffer 3 = 10- 15 km
Ring Buffer 4 = more than 15 km
where the proposed DART is planned to pass. The TAZ points were created to identify the ring buffers to which the different wards belong. The wards were selected based on the following three criteria.

- Wards with most dense residential zones along the proposed DART lines based on the study of (Logit, 2007) which indicated that the highest percentage of trips were generated by high dense residential areas in the city.
- Whether the wards had planned or unplanned residential zones to capture the socio-economic variation of the regular commuting residents which might have an impact on preference differences.
- The spatial location of the wards from the CBD where it was important to detect whether the residence location distance from the CBD had an influence on the choice of the respondent.

4.3. Field Work Stage

This stage covers entirely the field survey activities. This is an important stage of research where the required primary and secondary data has to be collected. Also the collected data has to be entered in data sheets for later processing and analysis.

4.3.1. Survey Implementation

Having got the survey questionnaire ready and sampling strategy designed, it was the right time to put the stated choice survey in implementation. It is concerned mainly with field primary data collection.

4.3.1.1. Field Survey Preparation

Before the survey, the questionnaires and sampling strategy were revised and amended based on the ideas and experiences gained after discussion with the local experts of the DART Agency, the group of surveyors and the JICA team and also the wards where the study was most relevant were fixed. The survey Questionnaires were prepared and made ready for training of interviewers and translation and it was at this time when arrangement for a training place and other necessary logistics were done.

Also a reconnaissance survey of the selected wards and proposed DART corridors was done to pick a general picture of the study area. Also, visiting local leaders was started at that time and done throughout the field work period. So this was done simultaneously with the surveying process and it was a difficult and necessary task since there was a need for permission to carry out survey in the different wards. Thus as soon as permission was given, the survey followed.

4.3.1.2. Recruitment and Training of Surveyors

To ensure the quality and validity of the data, capable interviewers (surveyors) were used. Four interviewers were recruited and trained for two days to make them understand the questionnaire and surveying techniques. The interviewers were selected graduate urban planning students from Ardhi University. As a training technique, the surveyors interviewed each other and also between them and their trainers where mistakes were observed and corrected. After, the interviewers had to translate the questionnaire themselves into Swahili and this further increased their understanding of the questionnaire since they had to discuss on the exact meaning of each phrase translated into Swahili.

The goals of the surveyors training were the following:

1. Making the interviewers understand the DART and specific research goals and strategy. It was necessary for the interviewer to be better informed about the subject, so that he can better approach and handle questions of respondents. This goal was realized by informing the interviewers about the DART system in relation with the current research goals. Based on that, an explanation was given of
the research technique (stated choice) to ensure that the interviewers understood the idea of the method.

2. Secondly it was to teach the interviewers the data collection technique (Face-to-face interview). Therefore, first the questionnaire set-up was explained to show the different parts of the questionnaire. After that the interviewers were instructed how to carry out the survey. This was followed by some test surveys, to recognize which common mistakes were made. By recognizing these mistakes during the training day, one could give instructions to the interviewers to avoid making the mistakes again.

3. The last goal was to get input from local people to achieve the field work objectives, especially in carrying out interviews since the researcher was not familiar with the study area, which might have been unsuccessful otherwise.

4.3.1.3. Pilot Survey

The objective of the pilot survey was to test the contents of the questionnaire and logistics of the survey process. The pilot survey was conducted in two residential zones of Ubungo one the selected wards and a total of 20 samples were collected by a team of 4 surveyors where each surveyor was requested to conduct 5 interviews. The following purposes were set for the testing of the questionnaire:

- To observe how respondents made their choice. If a large majority is choosing for the same alternative, it indicated poor trade-off. In such case the most chosen alternative should be made less attractive or the least chosen alternative should be made more attractive.
- To determine whether the non-stated choice part of the questionnaire was appropriate and understandable to the respondents.
- The survey was also intended to test: interview length; whether any additional questions required; respondent’s understanding of the questions; appropriate time to conduct survey; the threshold distance within which the survey should be conducted from the proposed DART line.

With respect to the interviewers, the following goals were set:

- This survey was intended to serve as a demonstration of the data collection method and to check interviewers’ understanding of the study and the survey exercise;
- Investigate whether the interviewers were enough to conduct the survey and also make them familiar with the survey exercise;
- To provide the interviewers information about how they can improve the survey after observing their mistakes during the survey.

Results of pilot survey

After the pilot survey, the questionnaire was revised and things that were unclear were discussed and thus served as a guiding tool for better preparation of the main survey. The questionnaire went under minor changes like it was shown that some trade-offs in the choice sets were not really equal and these had to be corrected, because all respondents were choosing the same alternative. The interviewers got used with the interviewing exercise as they attended to more people. However, some interviewers made mistakes like: not asking all the questions; forget to fill in the form occasionally. After the survey, the interviewers were informed about the mistakes made and corrected so that they didn’t repeat the mistakes in the main survey.
4.3.1.4. Main Survey

As a preparation of the main survey, a general observation and tour of the city developments along the BRT corridors was made. In some parts of the city, the BRT works had already started on Kilwa road and Morogoro Corridor where the road expansion and relocation of activities in the BRT construction space were in place. Necessary logistics required to carry out the survey like printing of questionnaires, transport arrangements, salaries for interviewers, supervision arrangements were all organized before the main survey.

The main survey kicked off and lasted for 10 days as earlier planned. The survey started in wards where survey permission had already been attained. The survey always commenced with interviewer briefing at the DART office before going to field. This was organized such that survey materials are provided in time and also mistakes and problems related to survey encountered the previous day could be sorted out. In total a team of 4 surveyors were employed to carry out the survey and each one was required to collect a minimum of 15 samples per day where the minimum total sample required to be collected per day was 60 to reach a set target of 600 samples of data. The survey started at 2.00 pm and ended at 7.00 pm so as to meet the target respondents in their homes given that the official working time ends at 3.00PM in Dar es Salaam. The interviewers had to arrive in the survey area 15 minutes before start of the survey which gave room for better preparation of the actual interview. The survey was carried out within 2km thresholds from the proposed BRT lines. In total 695 commuters were interviewed during the survey from 30 wards along the BRT corridors but only 684 well completed questionnaires were considered and taken for analysis and the remaining questionnaires were discarded.

Towards the completion of the main survey, a debrief meeting was convened with all interviewers and field supervisors to end the field survey. All the interviewers were given time to discuss issues regarding the whole survey process and to give any remarks about the whole exercise. Later they were thanked for their commitment and cooperation rendered during the whole survey period. Figure 4.5 shows the day to day working approach during the main survey.

![Diagram of Day to Day Working Approach during Main Survey](image-url)

Figure 4-5: Day to day Working Approach during Main Survey
4.3.1.5. Data Entry and Verification

The data entry and field survey were done simultaneously through out field work. Thus, collected data was entered immediately after field survey. Data was first checked and verified for mistakes and entered in a prepared excel data sheet during evening hours from field and morning hours before going to field in case survey permission had been secured earlier.

4.3.2. Collection of Secondary Data

Mainly reports and digital data sets about the DART System were collected from the DART agency in the Dar es Salaam City Council. The digital data collected were the BRT- Network all phases; Dar land use map; population map; Road network and ward map. Other secondary data in form of reports were got from Ardhi University and National Bureau of Statistics. This was carried out mostly after completion of primary data collection (field Survey Activities).

4.4. Post-Field Work Stage

This is a post survey stage where the remaining part is entirely desk research. The collected data from field has to be prepared and made ready for analysis for conclusions to be drawn.

4.4.1. Data Preparation

The first task in the post-field work was preparing the data collected for analysis. The major tasks were converting the questionnaire survey (primary) data into statistical environment required for data processing. The stated choice data was prepared in an excel data sheet and later converted into notepad format to be accepted for processing in a model estimation software, Biogeme. The travel and socio-economic data were also prepared in an excel data sheet and later exported for processing to SPSS statistical software.

The digital data sets collected from secondary sources were prepared and made ready for spatial analysis. The map data collected were in Arc GIS format and thus no format conversion was required. However since the maps used were obtained from different sources, the co-ordinate systems were different. So in some cases projections were defined and the different co-ordinate systems were transformed into the same working co-ordinate system, the WGS1984 Zone 37N. The data for the BRT Network were checked for topology rules and validated.

4.4.2. Data Analysis

The collected and prepared data were analysed in three stages. The first analysis looks at the spatial coverage of the proposed DART system using its attributes in a situation when the DART represented by the attributes is present in a route. The proximity and temporal measures of accessibility were used to assess the proposed DART spatial coverage. The buffer analysis techniques and the GIS network analysis of travel time were respectively used for proximity and temporal measures of accessibility.

The second analysis evaluates the proposed DART attributes by examining the perceptions and preferences of commuters based on the stated choice data. Also in this stage, the descriptive statistics were employed to analyse the socio-economic and travel characteristics of the sampled population based on the collected data.
The stated choice data was processed and analysed using a Multinomial Logit (MNL) model. This is by far the most used model for processing data from choice experiments in transportation research (Ben-Akiva and Lerman, 1985; Louviere et al., 2000). This model suggests that individuals choose the alternative that maximizes the individual’s utility. The Random Utility Model used is defined as follows:

\[ U_{bn} = V_{bn} + \varepsilon_{bn} \]

Where:
- \( U_{bn} \) = the utility of the BRT by an individual \( n \)
- \( V_{bn} \) = the systematic utility component of the BRT
- \( \varepsilon_{bn} \) = the non-observable utility component of the BRT
- \( n \) = Individual \( n \)
- \( b \) = BRT

The systematic part of utility \( V_{bn} \) depends on the attributes considered in the research and in this case is given by the equation:

\[ V_{bn} = \sum \beta_{bk} X_{bkn} \]

Where:
- \( V_{bn} \) = the systematic utility component of the BRT
- \( \beta_{bk} \) = the utility coefficient associated with attribute \( X_{bkn} \) of the BRT
- \( X_{bkn} \) = the attribute of the BRT
- \( k \) = the \( k \)th attribute of the BRT

The third analysis assesses the effectiveness of the proposed DART System based on commuters’ perceptions and preferences. The utility-based accessibility measures were employed for the spatial assessment of the DART System using the GIS spatial analysis techniques and descriptive statistics. In order to evaluate the effectiveness of the proposed DART system based on the preferences of the potential users (commuters), the stated choice model results were used as input in the GIS model for spatial analysis.

### 4.5. Concluding Remarks

Based on literature survey, this chapter has identified and discussed in detail the methodological framework and approach taken right from fieldwork preparation phase till data analysis phase. Thus, all the analysis procedures taken in the next chapters of this research were based on this methodological approach. The next chapter describes the situational analysis of the proposed DART System and its characteristics.
5. Situational Analysis of the DART System

5.1. Introduction

A key component in the emerging methods and techniques for better understanding transportation processes is geographical information systems (GIS). Whether it is an assessment of broad scale policies or link specific capacity, GIS are proving to be valuable transportation management and modelling platforms (Murray and Davis, 1998). In relation to public transport, Researchers have used GIS technology to measure accessibility of public transport, creating public transport routes, identifying optimum routes, optimising bus stops and spatial analysis of service level, measuring spatial equity and public transport management. Generally, at present its application in public transport planning and management has increased. Moreover GIS application in infrastructure planning is getting wider attention due to query and spatial operation capabilities. Hence its query, spatial analysis and network analysis capabilities make it an attractive tool for this research.

5.2. Proposed Attributes of the DART System

According to Logit (2007), in 30 years, Dar es Salaam will grow to 7.5 million inhabitants and 3 million trips per day and given the poor quality, less capacity and inefficient service offered by the current public transport system, if nothing is done, there will be chaos. Therefore the solution is the Dar Rapid Transit System which is aimed at providing a better quality service. This quality service will be based on the DART system attributes which are detailed in Logit (2007) transport study report. However, only the DART System spatial related attributes that were selected for study in this research will be analysed. The table below shows the proposed DART spatial attributes that were used for spatial analysis of the system.

Table 5-1: Proposed DART Spatial Attributes

<table>
<thead>
<tr>
<th>DART Attribute</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Speed</td>
<td>22 km/ hour</td>
</tr>
<tr>
<td>Proposed Service area by each stop</td>
<td>500 m buffer</td>
</tr>
</tbody>
</table>

5.3. Proposed Spatial Coverage of the DART System

A major factor in assessing the effectiveness of public transport is the spatial coverage (distribution) of the service. Spatial coverage measures the ease with which the service can be reached at different locations and also measures spatial equity. It determines the access walking time and walking distance to get the service. The higher the spatial coverage of the public transport service, the shorter the walking time to get the service and the better is the service and the reverse is true. Based on Logit (2007), the proposed area of service by the DART system is 500 meter distance buffer of bus stop, hence in this situational analysis of the proposed system, proximity measures will be employed to assess the spatial coverage. However, other factors such as route density, number of routes per road
segment, trip frequencies etc. also should have been used to evaluate the spatial coverage in a more complete way. Due to the limitation of the available data and given the hypothetical situation of DART, only the proximity measures were possible to be used.

5.3.1. Proximity Analysis of the DART System

Proximity is an accessibility measure which shows the spatial extent of the service. Proximity measures the closeness of the service to either origins or destinations of people. In proximity analysis, the public transport service is strictly available at the DART stops. In this case, commuters will only access the DART at stops.

Data preparation

First, the data was required to be prepared for proximity analysis. The proximity analysis required data for the DART network stops and the area of service by the DART system. The DART network system data set was collected in Arc GIS format and thus no format conversion was required. However, the DART network data set obtained from DART Agency and other data sets obtained from ITC had different co-ordinate system since were obtained from different sources. Therefore, projections were defined and the different co-ordinate systems were transformed into the same working co-ordinate system, the WGS1984 Zone 37N. The DART network data set comprised of six different layers of the DART phases and the DART stops. These layers were merged together to form one single layer of the DART network. The DART network was prepared and topology rules were checked and validated. Also, the 2002 Dar es Salaam land use and population data were prepared and used for spatial analysis. The existing Dar es Salaam minor roads and foot path network data sets from ITC created by Amer et al. (2007) during his PhD research was checked and prepared to be used in analysis.

Modelling Approach

Proximity of people to the service can be measured using simple buffer analysis based on air line distance. However, this has a limitation that buffering considers only direct path or the geometric distance to stops but in reality people walk along roads and foot paths to get service at stops. Therefore, it is better to measure walking time following roads and foot paths. Hence, proximity to DART Stops was computed using the minor road net work distance along which commuters walk from their origins or destinations to reach the DART stop and by considering the population density. The service area of the DART stops was determined using the network analysis by computing the walking time to DART Stops. The service area buffers were compared to the land use map and population map to assess what proportion of planned and unplanned residential zones, mixed use areas and population served under each walking time class.

However, some assumptions were made to make this analysis possible. It was assumed that commuters behave rationally and walk to the nearest DART stop; secondly, it was assumed that the population is uniformly distributed in the service zones and thirdly the walking speed in Dar es Salaam city was assumed to be 4 km/hour. This assumption was based from other studies done earlier in the same study area (Amer et al., 2007). Also the 2002 population used in this analysis was assumed to remain constant till the time of DART is in place for practical reasons. The analysis procedures and map results are shown by figure 5-1 and figure 5-3 below respectively. The analysis results from the proximity map are summarised in tables and graphs for interpretation and discussion.
Discussion of Results

By computing the service area of each DART Stop using the network analyst, the total area within each proximity zone of walking time was determined. Based on proximity analysis results Table 5-2 and Figure 5-3, about 39% of the total area is covered within 10 minutes walking time to the DART stops. This means, assuming the average walking speed of 4 km per hour, this proportion is covered within a distance close to 500 meters.

Table 5-2: Area Coverage by Proximity to DART Stops

<table>
<thead>
<tr>
<th>Walk time to DART Stops (minutes)</th>
<th>Area</th>
<th>Cumulative Area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>11.15</td>
<td>11.15</td>
</tr>
<tr>
<td>5 - 10</td>
<td>27.78</td>
<td>38.93</td>
</tr>
<tr>
<td>10 - 15</td>
<td>26.29</td>
<td>65.22</td>
</tr>
<tr>
<td>15 - 20</td>
<td>13.24</td>
<td>78.46</td>
</tr>
<tr>
<td>20 - 25</td>
<td>10.74</td>
<td>89.2</td>
</tr>
<tr>
<td>25 - 30</td>
<td>10.8</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5-2: Area Coverage by Proximity to DART Stops
Figure 5-3: Proximity to BRT (DART) Stops based on road network
Armstrong-Wright et al. (1987) suggests that the walking distance for well served urban areas should be in range of 300 to 500m. From Table 5-2 and Figure 5-3, it is shown that around 65% of the total area is covered within 15 minute walking time to the DART Stops equivalent to 1000 meters walking distance assuming a walking speed of 4 km per hour. According to Armstrong-Wright et al. (1987), a walking distance more than 500 m is still acceptable but should not exceed 1000 m. However, the remaining 35% of the total area (Table 5-2) above lies in more than 15 minutes walking time (1000 m) to DART Stops.

Table 5-3: Area Coverage for Planned and Unplanned Residential by Proximity to DART Stops

<table>
<thead>
<tr>
<th>Walk Time to DART Stops (Minutes)</th>
<th>Area covered Planned R. (%)</th>
<th>Cumulative Area covered Planned R. (%)</th>
<th>Area covered Unplanned R. (%)</th>
<th>Cumulative Unplanned R. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>14.48</td>
<td>14.48</td>
<td>8.66</td>
<td>8.66</td>
</tr>
<tr>
<td>5 - 10</td>
<td>32.22</td>
<td>46.7</td>
<td>23.39</td>
<td>32.05</td>
</tr>
<tr>
<td>10 - 15</td>
<td>26.5</td>
<td>73.2</td>
<td>24.85</td>
<td>56.9</td>
</tr>
<tr>
<td>15 - 20</td>
<td>9.86</td>
<td>83.06</td>
<td>16.3</td>
<td>73.2</td>
</tr>
<tr>
<td>20 - 25</td>
<td>7.81</td>
<td>90.87</td>
<td>14.45</td>
<td>87.65</td>
</tr>
<tr>
<td>25 - 30</td>
<td>9.12</td>
<td>100</td>
<td>12.34</td>
<td>100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5-4: Area Coverage within Planned and Unplanned Residential Zones

Table 5-3 and Figure 5-4 show the Area coverage within planned and planned residential by the DART service based on proximity to the DART Stops using walking time. It is shown that around 47% of planned residential zones and 32% of unplanned residential zones in the study area are covered within a walk time of 10 minutes while around 73% of planned residential and 57% of unplanned
residential zones are covered within 15 minutes walk (1000 m) to the DART Stops. It is also shown that the remaining 27% of the planned residential and 43% of unplanned residential falls beyond 15 minute walk time to the DART stops.

Table 5-4: Population Coverage by Proximity to DART Stops

<table>
<thead>
<tr>
<th>Walk Time to DART Stops (Minutes)</th>
<th>Population (%)</th>
<th>Cumulative population (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>12.21</td>
<td>12.21</td>
</tr>
<tr>
<td>5 - 10</td>
<td>32.06</td>
<td>44.27</td>
</tr>
<tr>
<td>10 - 15</td>
<td>25.45</td>
<td>69.72</td>
</tr>
<tr>
<td>15-20</td>
<td>12.67</td>
<td>82.39</td>
</tr>
<tr>
<td>20 - 25</td>
<td>10.23</td>
<td>92.62</td>
</tr>
<tr>
<td>25 - 30</td>
<td>7.38</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5-5: Population Coverage by Proximity to DART Stops

Table 5-4 and Figure 5-5 show the proximity of population to the proposed DART Service based on the walking time from their origin to the DART stops. It is shown that about 44% of the population will access the DART Service within 10 minutes walk time which is closer to a distance of 500 m assuming a walking speed of 4 km per hour while nearly 70% of the population will walk up to 15 minutes (1000 m) to get the DART Service. It also shows that around 30% of the population will have to walk more than 15 minutes to get the DART service. However, Armstrong-Wright et al. (1987) states that the maximum walking distance should not exceed 1000m.

From Table 5-4 above, it is also shown that around 82% of the population will access the DART Service within 20 minutes walking time to the DART Stops. From the field survey results (chapter 5, Table 6-2), it was revealed that around 83% of the population access the existing public transport service within 20 minutes walking time to bus stops. Comparing the proximity analysis and survey analysis results based on walking time, it can be concluded that more than 80% of the Dar es Salaam population are located within 20 minutes walking time to the DART Service (DART stops). This is around 1.3 km walking distance to the DART Stops assuming a walking speed of 4 km per hour.
Table 5-5: Population Coverage in Planned and Unplanned Residential by Proximity to Stops

<table>
<thead>
<tr>
<th>Walk Time to DART Stops (Minutes)</th>
<th>Population Planned R. (%)</th>
<th>Cumulative Planned R. (%)</th>
<th>Population Unplanned R. (%)</th>
<th>Cumulative Unplanned R. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>15.73</td>
<td>15.73</td>
<td>10.19</td>
<td>10.19</td>
</tr>
<tr>
<td>5 - 10</td>
<td>32.08</td>
<td>47.81</td>
<td>30.95</td>
<td>41.14</td>
</tr>
<tr>
<td>10 - 15</td>
<td>25.56</td>
<td>73.37</td>
<td>21.75</td>
<td>62.89</td>
</tr>
<tr>
<td>15 - 20</td>
<td>10.07</td>
<td>83.44</td>
<td>16.68</td>
<td>79.57</td>
</tr>
<tr>
<td>20 - 25</td>
<td>8.32</td>
<td>91.76</td>
<td>13.09</td>
<td>92.66</td>
</tr>
<tr>
<td>25 - 30</td>
<td>8.24</td>
<td>100</td>
<td>7.34</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

Table 5-5 illustrates the population coverage within Planned and unplanned residential zones in the different walk time ranges to get the DART service. It is shown that nearly 48% of the planned residential population and 41% of the unplanned residential population is likely to access the DART service within 10 minutes walking time. It also shows that around 73% of the planned residential population and 63% of the unplanned residential population are covered by the DART Service within walking time of 15 minutes. This indicates that the planned residential population is likely to have more access to the DART service than population in the unplanned residential zones.

Table 5-6: Proportion of Residential Population Coverage compared to the Total Population

<table>
<thead>
<tr>
<th>Walk Time to DART Stops (Minutes)</th>
<th>Residential population (%)</th>
<th>Total population (%)</th>
<th>Cum. Population Residential (%)</th>
<th>Cum. Total Population (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 5</td>
<td>8.2</td>
<td>12.21</td>
<td>8.2</td>
<td>12.21</td>
</tr>
<tr>
<td>5 - 10</td>
<td>20.5</td>
<td>32.06</td>
<td>28.7</td>
<td>44.27</td>
</tr>
<tr>
<td>10 - 15</td>
<td>15.2</td>
<td>25.45</td>
<td>43.9</td>
<td>69.72</td>
</tr>
<tr>
<td>15 - 20</td>
<td>9</td>
<td>12.67</td>
<td>52.9</td>
<td>82.39</td>
</tr>
<tr>
<td>20 - 25</td>
<td>7.2</td>
<td>10.23</td>
<td>60.1</td>
<td>92.62</td>
</tr>
<tr>
<td>25 - 30</td>
<td>5</td>
<td>7.38</td>
<td>65.1</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>65.1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5-6: Population Coverage in Residential compared to Total Population by Proximity to Stops
Table 5-6 and Figure 5-7 shows the proportion of population in the residential zones (planned and unplanned) that are covered by the proposed DART Service within different walking time ranges compared to the total population. It is shown that nearly 29% population in the planned and unplanned residential zones get the DART service within 10 minutes walking time while the total population likely to be served by the DART service within 10 minutes walking time is 44.27%. This indicates that 15.57% constitutes the other urban population likely to have good access to the DART Service. It is also shown that nearly 44% population in residential zones is likely to have access to the proposed DART service with in 15 minutes walking time compared to around 70% of the total population. From the results one can also tell that 21.2% of the residential population is likely to walk more than 15 minutes to get the DART service compared to 30% of the total population in the study area.

5.4. Conclusive Remarks

This chapter has investigated the spatial coverage of the proposed DART Service in relation to the residential areas of the city of Dar es Salaam. To assess the proposed spatial coverage of the DART service, proximity analysis has been employed. Based on the analysis results, proximity to the proposed DART Service is not a major problem. Almost 70% of the total population are within 15 minutes walking time to the proposed DART Service. Although this shows that more population will access to the DART service, still 30% of the total population will have limited access most of whom are located in the city peripherals.

Also, it is shown that around 73% of the population in planned residential zones will have more access to the DART service compared to 63% of the population in the unplanned residential areas mostly occupied by the low income people. Consequently, one can say that the population in the unplanned residential areas will be disadvantaged since they have a high proportion of people with 37% who have to walk more than the acceptable walking time of 15 minutes to get the DART service compared to 27% from planned residential zones.

It is also found out that nearly 39% of the total area is covered within 10 minutes walking time to get the DART Service while a total area of around 65% is covered by the DART Service within 15 minutes walking time. It was also shown that the area under planned residential (47%) will be covered by the DART service more than unplanned residential area (32%). However, the lower the spatial coverage of the DART system, the higher the walking time to get the DART Service and the less access the service will be rendered.

Although proximity analysis has been used to assess the spatial coverage of the DART service, proximity does not give the right indication about the type and level of service supplied by the transport system. It only checks the walking time taken from the origin of a commuter to the DART stops. Therefore, in order to get better results of measuring accessibility, it is necessary to combine the proximity analysis with other parameters which measure other aspect of accessibility. These include quality of service, consumers’ preferences, equity and infrastructure availability. However, given the hypothetical condition of the DART system, it would be difficult to evaluate the transport system by combining the different accessibility parameters. In this case it was possible to examine commuters’ attitudes and preferences towards the DART service by stated choice analysis techniques in the next chapter.
6. Stated Choice Analysis

6.1. Introduction

In this chapter, the attitudes and preferences of commuters towards the proposed DART System and its characteristics are examined. This is carried out to identify the likelihood for the people to use the DART Service and the value attached to the DART System attributes. A Stated Preference approach was taken to collect attitudes and preferences of the DART potential users through a stated choice questionnaire. The stated choice questionnaire also consisted of some questions to collect information related to the travel behavior and socio-economic characteristics of the sampled population as discussed earlier in chapter 4. In the next section, the socio-economic and travel characteristics of the sampled population are analyzed and discussed in detail.

6.2. Characteristics of the Sampled population

Even though the socio-economic and demographic characteristics are not thought to be important in Utility/preference formation, collecting such information is a worthwhile exercise (Hensher et al., 2005). While this may place an additional burden to the respondents through an increase in survey length, such data can often be useful in checking whether the sample collected matches the known characteristics of the population of interest (Hensher et al., 2005).

Therefore, the data from the survey was analysed statistically to get an insight on how the sampled population varied based on their socio-economic, demographic and travel characteristics and to check whether the collected sample characteristics matches with those of Dar es Salaam Population. The data samples were descriptively analysed using SPSS and later the results were summarised in tables and graphs in excel sheet. The results of the socio-economic and demographic characteristics are discussed in the next section of this chapter.

6.2.1. Socio-Economic and Demographic Characteristics

The results of the socio-economic and demographic characteristics are summarised in Table 6-1 below and also shown graphically under figure 6-1 below.

The results of the survey in terms of gender show relatively good representation of male and female respondents in the collected samples and also the small variations shown by the comparison between the sampled population and the entire population of Dar es Salaam indicates a relatively good representative sample. The variation in the employment status of the sampled population show that all groups were represented, and compared to the city population small difference in most of the variables except in the case of self-employed where most samples were collected (44.7%). This is because the target group were people who commute regularly to CBD and most of these people are businessmen and petty traders self employed by running their own business down town. Secondly, it is reported that about 95 % of City residents are working in the informal sector and only 5% in the formal sector which could be another reason for the difference in figures (Dar es Salaam City Council, 2004).
Most respondents were between 26 and 64 years of age as expected since this is the working age group which indicates good data in the point of view of this research. Population below 26 years is taken to be dominated by students from view of a developing country and thus one would expect that this group travels less to the CBD and more so for the old people with age higher than 64 years. Compared to the city population, the sampled population is a relatively good representation in terms of Age. However, Age group lower than 14 years were not considered in the survey because it would be difficult to interview this group given the nature of the survey and also given that the travel characteristics of this age group depends on the decision of their parents.

The result shows that a higher percentage of respondents had completed their secondary level compared to the city population; the higher percentage was reported for primary level. This difference could be because of the nature of study since the survey in this research was targeting regular commuters to CBD and most of the respondents were employees of the private and public sector which one would expect to have an education level above primary in the city. Thus the sampled population represents people commuting to CBD regularly and does not represent the entire population of Dar es Salaam. However, many respondents with higher education level in the sampled population would represent regular commuters to CBD where most of the public and private institutions are located and this group could have a big effect on the use of the proposed BRT, thus modelling their stated choice would be important in view of this research.

From the results, it is indicated that most of the respondents were from low income class, followed by middle class and less respondents from the high income class during the survey as expected especially for the case of Dar es Salaam city in particular and in developing cities in general. However, there were no data from other studies to make comparisons with the city population. The Income groups were classified based on the classification criteria from the National bureau of statistics, Dar es Salaam which mainly based on Ownership of Assets rather than on cash Income. Though Monthly income in cash was asked from respondents, it was not used in the income grouping classification given that it is usually over or under reported especially in developing countries and also the fact that it was difficult to get income classification thresholds for Dar es Salaam. Therefore a classification based on ownership of Assets was employed and the monthly income earned by the respondent was used as a check for the information given. However, it was difficult to include all questions related to Income classification given the complexity of the stated choice survey as this could lead to respondent fatigue. Also a more detailed survey aiming to socio-economic classification would need more time and financial resources that are beyond those available in this research. Therefore, the income classes created give an idea of the socio-economic fabric of the sampled population and do not represent the economic classes of the entire city.

From the survey results 86% of the respondents do not own a vehicle and about 70% do not own house which is not surprising in the case of Dar es Salaam mostly dominated by low income residents according to ground statistics. In comparison to the entire city, Vehicle and House ownership characteristics in the sampled population represents well the city population. “Vehicle Ownership is defined as a Personal car, Trucks, Tractors, Trailers, motorcycle owned by an individual respondent; House ownership means personal house owned by the individual respondent”
Table 6-1: Socio-economic and Demographic characteristics of the Survey samples compared with Dar es Salaam Population.

Comparison of Sample Respondents with Dar es Salaam Population

<table>
<thead>
<tr>
<th>Factor</th>
<th>Percentages(%) with in Samples of respondents</th>
<th>Percentages(%) with in Dar es Salaam Population</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Socio-Economic Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>53.7</td>
<td>50.5</td>
</tr>
<tr>
<td>Female</td>
<td>46.3</td>
<td>49.6</td>
</tr>
<tr>
<td>Age Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 - 25 years</td>
<td>30.3</td>
<td>36.5</td>
</tr>
<tr>
<td>26 - 64 years</td>
<td>68.1</td>
<td>60.4</td>
</tr>
<tr>
<td>&gt;64 years</td>
<td>1.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Employment Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full time</td>
<td>21.2</td>
<td>22.1</td>
</tr>
<tr>
<td>Part Time</td>
<td>12.9</td>
<td>Data not available</td>
</tr>
<tr>
<td>Self-employed</td>
<td>44.7</td>
<td>22.8</td>
</tr>
<tr>
<td>Unemployed</td>
<td>3.9</td>
<td>2.5</td>
</tr>
<tr>
<td>Student</td>
<td>11.8</td>
<td>11.5</td>
</tr>
<tr>
<td>Retired</td>
<td>5.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Other</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Education Level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No education</td>
<td>1.3</td>
<td>7.6</td>
</tr>
<tr>
<td>Primary</td>
<td>32.3</td>
<td>60.6</td>
</tr>
<tr>
<td>Secondary school</td>
<td>44.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Higher</td>
<td>21.2</td>
<td>2.9</td>
</tr>
<tr>
<td>Missing data</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Income Class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Income</td>
<td>62.3</td>
<td>Data not available</td>
</tr>
<tr>
<td>Middle Income</td>
<td>23.7</td>
<td></td>
</tr>
<tr>
<td>High Income</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Vehicle Ownership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own vehicle</td>
<td>14</td>
<td>7.3</td>
</tr>
<tr>
<td>No vehicle</td>
<td>86</td>
<td>92.7</td>
</tr>
<tr>
<td>House</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own house</td>
<td>32.3</td>
<td>29.3</td>
</tr>
<tr>
<td>No house</td>
<td>67.7</td>
<td>70.7</td>
</tr>
</tbody>
</table>

Source: Population & Housing Census 2002

Source: household budget survey, 2000/01
ANALYSING COMMUTERS' ATTITUDES TOWARDS THE PROPOSED BUS RAPID TRANSIT SYSTEM

Figure 6-1: Socio-Economic and Demographic Characteristics of the Sample
6.2.2. Travel Characteristics

The survey results of Travel Characteristics are summarised in Table 6-2 below and also indicated graphically under figure 6-2 below.

Table 6-2: Travel Characteristics of the Sampled Respondents

<table>
<thead>
<tr>
<th>Factor</th>
<th>Percentages(%) with in Samples of respondents</th>
<th>Percentages(%) with in Dar es Salaam Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Trip Purpose to CBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work</td>
<td>28.5</td>
<td>Data not available</td>
</tr>
<tr>
<td>School</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>Business</td>
<td>49</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>12.9</td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Access Walk Time to Nearest Bus Stop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within 0-10 minutes</td>
<td>52.8</td>
<td>PT is used only by people that live within 20 min. walk dist. to bus stop = 96%</td>
</tr>
<tr>
<td>Within 10-20 minutes</td>
<td>30.4</td>
<td></td>
</tr>
<tr>
<td>Within 20-30 minutes</td>
<td>9.5</td>
<td></td>
</tr>
<tr>
<td>&gt; than 30 minutes</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Mode of Travel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daladala</td>
<td>87.9</td>
<td>42</td>
</tr>
<tr>
<td>Bicycle</td>
<td>0.3</td>
<td>3</td>
</tr>
<tr>
<td>Walking</td>
<td>1.8</td>
<td>46</td>
</tr>
<tr>
<td>Private Car</td>
<td>8.9</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Missing data</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>


Figure 6-2: Travel Characteristics of the Sample
The statistics from the survey show that most commuters travel to the CBD for business (large-scale business, petty traders, business shopping) activities. Those who travel to CBD for Office work activities that is government and non-government institutions constitute about 29% of the total respondents, while school trips count for about 10%, the remaining others contribute 13%. The reasons for this distribution of trips can be justified by the employment status of the commuters earlier discussed under section 6.2.1.

It is observed from the analysis of access walk time to the nearest bus stop that more than 80% of the sampled population are located within 20 minute walk time distance to the nearest bus stop which does not differ from other study findings which indicates that 96% of the population live with in 20 minutes walk time the nearest bus stop (Amer et al., 2007). Only about 13% walked beyond 20 minutes to the nearest bus station.

The access travel characteristics of the survey samples were also analysed on the basis of travel mode to CBD. Although Kaltheier (2002) in his research found out that most people in the city travel by walking compared to public transport use as shown in table 6-2 and graph 6-2(a), this has appeared differently in this research and does not relate to the sampled population whereby the percentage of public transport users is expected to be higher than that of other modes. Therefore, in this study nearly 88% of the commuters access the CBD by public transport (Daladala); 8.9% private car; 1.8% by walking; 0.3% by bicycle and 1% other modes. This is a good result in view of this research as one would assume that most of the daladala commuters would be the potential riders of the proposed DART and thus modelling their travel choice behaviour would be meaningful and reasonable.

This sub chapter has discussed the socio-economic, demographic and travel characteristics of the sampled population. From these results, there are no reasons to believe it was an untypical group of respondents. Therefore, the next sub chapter discusses stated choice analysis and thus model estimations should produce robust results because the different socio-economic groups in the population are represented in the sample and also given the big variation in characteristics of the sample.

### 6.3. Stated Choice Modelling

The DART System is a true innovation in Dar es Salaam. In this case, it is not appropriate to base forecasts of its impact on observations of existing revealed preferences. Therefore, it was necessary to obtain data from surveys of hypothetical situations which include the innovation (its attributes) to assess its impacts on travel choice behaviour.

Based on the objective of the study which focuses entirely on analyzing commuters’ travel preferences towards the proposed attributes of the Dar Rapid Transit (DART), a binary choice model was constructed where an individual had to choose between two alternate set of attribute options of the hypothetical mode (DART) since there will be no alternative mode option. This is because the public transport policy in Dar es Salaam suggests that the DART will hardly have any competition from other public modes operating alongside it and also given its long run city coverage.
Using a stated choice approach, a total of 684 commuters were interviewed and each individual commuter was presented nine (9) choice sets where he/she had to state his or her choice on the different alternate options of the DART attributes during the survey. This resulted to 6155(Q) observations of stated choice data that was prepared and later entered in the model. The data collected provided information to analyse the impact of the modal innovation in transportation “the DART” in relation to commuters’ attitudes and preferences.

The Multinomial Logit (MNL) was employed to model the attitudes and preferences of the commuters through their stated choices. The model was used to derive a polynomial linear Utility function and estimation of the relative importance of the DART attributes, however, could not be used for estimation of modal choice probabilities since there are no alternatives to DART considered in this study.

Modeling of Stated Choice was done based on the spatial and socio-economic differences of the individual commuters. This was done purposely to examine the differences in preferences of the commuters in the different spatial locations of the city and by their different socio-economic classes. Also, based on the reviewed literature, generally, discrete choice models postulate that: the probability of individuals choosing a given option is a function of their socioeconomic characteristics and the relative attractiveness of that option (Ortúzar and Willumsen, 1994). Therefore, in order to obtain a proper insight in the travel choice behaviour of the DART potential users, it was necessary to analyse their stated preferences first at city level, secondly on the basis of their spatial location differences and thirdly based on their socio-economic differences.

6.3.1. Model Input Variables

The variables entered in the model are the proposed DART attributes that have been considered important to study in this research earlier discussed in chapter 4 (refer section 4.2.3.3). Four variables were used to specify the utility of the DART. The choice attributes used were: access walking time to BRT stop, In-vehicle travel time, Travel Fare and comfort which were all varied over three levels.

However, it was observed during field survey that respondents were combining the access walk time to BRT stop and the in-vehicle travel time attributes when making choice of the presented choice sets. Since respondents could not differentiate these attributes while making choice, the researcher thought it was reasonable to combine the two attributes after the survey in order to capture the actual choice behaviour of the sampled population given that they were interested in the total travel time. Therefore, these two attributes were later combined to give the Total BRT Travel Time that was used for choice modelling. Also modelling these two attributes differently, would not reflect the real choice behaviour of the respondents as actually made on the ground which could have led to statistically inefficient model results.

In this binary choice model it was assumed that Total travel time (access walk time + In-vehicle travel time), Travel fare and comfort attributes of the DART System are the only factors influencing the mode choice. It was also assumed that the coefficients of the explanatory variables are generic, i.e they do not vary among the alternate attribute choice sets. Table 6.3 below shows model input variables.
Table 6-3: Variable definition

<table>
<thead>
<tr>
<th>Attribute name</th>
<th>Unit</th>
<th>Type of Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>Minutes</td>
<td>Quantitative</td>
<td>Total BRT travel time to CBD (Walk time to BRT stop + In vehicle travel Time) one way</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>Tsh.</td>
<td>Quantitative</td>
<td>Total BRT Travel Fare to CBD (one way)</td>
</tr>
<tr>
<td>Comfort</td>
<td>Level of Comfort</td>
<td>Qualitative</td>
<td>Seat guaranteed, Comfortable Standing, Overcrowded Standing (when inside the bus).</td>
</tr>
<tr>
<td>Error term</td>
<td>-</td>
<td>-</td>
<td>Error term</td>
</tr>
</tbody>
</table>

Tsh. = Tanzania Shillings 1 US Dollar = 1200 Tsh (approx.) as of September, 2007

6.3.2. Defining the Basic Utility Model Expression

The Random Utility Model (as defined in Chapter 2; equation 2.1) and also described under methodology (refer to section 4.4.2) suggests that individuals choose the alternative that maximizes the individual’s utility. The Multinomial Logit model was thus necessary to process the stated choice data to derive the utility function. Given that there were only two choice alternate attribute options of the hypothetical DART, a binary logit model was used. To derive the utility, the $\beta$-values needed to be estimated. This was done by using the maximum likelihood method for the MNL model (Louviere et al., 2000). The Utility function used was expressed as:

$$U_{BRTi} = \varepsilon_{bi} + \beta_{TT}TT_{BRTi} + \beta_{FARE}FARE_{BRTi} + \beta_{CFT}CFT_{BRTi}$$  \hspace{1cm} (6.1)

Where:

- $U_{BRTi}$ = Utility of BRT
- $TT_{BRTi}$ = Total Travel Time of BRT (one way)
- $FARE_{BRTi}$ = Total Travel Fare of BRT (One way)
- $CFT_{BRTi}$ = Comfort of the BRT
- $\beta_{TT}$ = Weight or coefficient associated with attribute Travel Time
- $\beta_{FARE}$ = Weight or coefficient associated with attribute Travel Fare
- $\beta_{CFT}$ = Weight or coefficient associated with attribute Comfort
- $\varepsilon_{bi}$ = Error term
- $i$ = Residential Zone $i$ (TAZ $i$)
- $bi$ = Buffer Ring $i$

This utility expression was used to determine the total utility of the BRT. Therefore, the higher the Utility value, the more the BRT is preferred by the sampled population. A higher utility value means that the BRT attributes are more attractive to the individual commuters and thus a more preferred option. On the other hand, the lower the Utility value, the less the BRT is preferred meaning that the BRT attributes are less attractive to its potential users i.e. the commuters.
6.3.3. Estimation of Utility Model and Result Discussion

This section presents the results of the BRT choice utility model. The main effects of the variables (BRT attributes) are discussed with respect to the directionality of effect and their relative magnitudes and willingness to pay values. The main effects model serves as an important point for analysing the importance of each variable relative to one another. The results are discussed in the next five sub sections.

The estimation of the Utility model was done in three cases; the first was model estimation based on deriving a generalised utility function of the whole city, second was model estimation to derive utility functions based on spatial differences in locations of the sampled population in reference to distance from CBD. Thirdly, was model estimation to derive utility functions based on the socio-economic differences of the sampled population.

In all the three cases, the results were analysed using Michel Bierlaire Biogeme Version 1.5. The stated choice data was analysed using the Binary Logit model. Along with the Utility parameter estimates and their corresponding levels of significance, Biogeme also provides all of the basic post-estimation statistics, including the goodness-of-fit indicator ($\rho^2$). The utility model required to perform nine iterations to reach a solution. In each case, the model estimation results will be shown and discussed.

Also, the estimated utility expression was processed to identify the impact of a change in one or more attributes of the BRT on market shares. The Willingness To Pay (WTP) value for travel time attribute of the BRT ($WTP_{TTbrt}$) which is the marginal rate of substitution between travel time and travel fare is given by the ratio of the travel time utility parameter ($\beta_{TTbrt}$) and the travel fare utility parameter ($\beta_{Farebrt}$) and likewise the WTP values for comfort ($WTP_{CFTbrt}$) was given by the ratio of comfort utility parameter ($\beta_{CFTbrt}$) to fare utility parameter ($\beta_{Farebrt}$) (Louviere et al., 2000). The Willingness To Pay (WTP) Values was given by:

\[
WTP_{TTbrt} = \frac{\beta_{TTbrt}}{\beta_{Farebrt}}; \quad WTP_{CFTbrt} = \frac{\beta_{CFTbrt}}{\beta_{Farebrt}}
\]

6.3.3.1. Model Estimation based on the Total sampled population of the city

Modeling Approach

The modeling approach taken in this case was aimed at analysing the stated preferences of the sampled population i.e. the individual commuter respondents at an aggregated city level. This was done purposely to examine the attitudes and preferences of the BRT potential users to get a general view on how the BRT introduction will have an effect on their travel behaviour at the city level.

The data samples collected from different zones of the study area were aggregated together into one big sample data set which consisted of 684 data samples. Since each of the sampled individual
commuters was presented nine choice sets, this resulted into 6156 observations. The whole stated choice data set was then prepared and entered into the model using Biogeme software for analysis. The results of the Maximum Likelihood estimation of the model were discussed and summarized in table 6-4 shown below.

Table 6-4: Model Estimation Results for the total sampled population

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Value</th>
<th>WTP Value</th>
<th>Units</th>
<th>t - test</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>$\beta_{TT}$</td>
<td>- 0.0487</td>
<td>30.2</td>
<td>Tsh/min</td>
<td>-17.75</td>
<td>0.00</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>$\beta_{FARE}$</td>
<td>- 0.00161</td>
<td>-</td>
<td>-</td>
<td>-5.16</td>
<td>0.00</td>
</tr>
<tr>
<td>Comfort</td>
<td>$\beta_{CFT}$</td>
<td>0.552</td>
<td>343</td>
<td>Tsh/unit of CFT</td>
<td>10.38</td>
<td>0.00</td>
</tr>
<tr>
<td>Error term</td>
<td>$\epsilon_{bn}$</td>
<td>1.06</td>
<td>26.24</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No. of estimated Parameters: 4
No. of observations: 6156
Null log-likelihood: -4266.321
Init log-likelihood: -4266.321
Final log-likelihood: -2652.603
Likelihood ratio test: 3227.436

Rho-Square ($\rho^2$): 0.378

Utility Parameter Values

All attributes and the error term ($\epsilon_{bn}$) have t-statistics greater than 1.96 (more than 95 percent confidence). Overall the model has a likelihood ratio-Index $\rho^2$ (pseudo-$R^2$) of 0.378 when comparing the log likelihood at Zero and the log likelihood at convergence which indicates a good model fit (Louviere et al., 2000).

The signs of all the utility parameters are correct as shown in the model output Table 6-4 above. One would expect that a negative sign would be associated with travel time and Travel Fare since an individual’s relative utility will increase when travel time and travel fare decreases (and vice-versa). Also one would expect a positive sign associated with comfort as an individual’s relative utility will increase with increase in the level of comfort (and vice versa).

Willingness to Pay (WTP) Values

The estimated utility expression is processed to identify the impact of a change in one or more attributes of the DART on market shares. The marginal rate of substitution between travel time and travel fare is given by the ratio of the travel time utility parameter and the travel fare utility parameter (Louviere et al…, 2000). The Willingness to Pay Values are shown in Table 6-4 above.

The value of travel time savings for the BRT is given by ($-0.0487$ utiles per minute)/ ($-0.00161$ utiles per Tsh) or 30.2 Tsh per minute. This converts to 1,812 Tsh per person hour and thus tells that a sampled individual is willing to pay, on average, 1,812 Tsh to save one hour of time spent traveling to CBD ceteris paribus(holding other potential factors constant). In the same way, a sampled individual is
willing to pay **343Tsh** per unit of comfort ceteris paribus. This tells that, on average a sampled individual is willing to pay 343 Tsh to gain a unit level of comfort. From the results one can also tell that a sampled individual is willing to pay, on average, 11.3 times more to gain a unit level of comfort than to save a unit of travel time.

**Deriving the Utility function**

Since the utility parameters (betas) were estimated, the next step was to derive the Utility function. From the basic utility model expression (equation 6.1) defined in section 6.3.2, given the estimated parameter values related to the BRT attributes, the Utility of the BRT is given by the following Utility expression:

\[
U_{BRT}^i = -0.0487T_{BRT}^i - 0.00161FARE_{BRT}^i + 0.552CFT_{BRT}^i + 1.06
\]  

(6.2)

This utility expression was used to determine the total utility of the BRT. In this case a high utility value indicates that the commuters more preferred the BRT and thus the BRT will be more attractive to its potential users. On the other hand, a lower Utility value indicates that the commuters less preferred the BRT meaning that the BRT will be less attractive to its potential users i.e. the commuters.

**6.3.3.2. Model Estimation based on the spatial location differences of the samples.**

**Modeling Approach**

The approach taken in modeling stated choice data related to spatial characteristic differences of the individual commuter respondents in the study area was based on the radial distance of their residential locations from the CBD as a point of reference in this study. The study area was earlier divided into four ring buffers during the survey in which the stated choice data was collected namely: Zones within 5km distance from CBD; Zones located within (5-10) km distance from CBD; Zones located within (10-15) km distance from CBD and Zones located more than 15km from CBD. Therefore, the stated choice data from each of the four buffers was modeled differently, the reason being that one wanted to investigate if there are differences in preferences of the sampled population based on their spatial locations from CBD. Therefore, the assumption made here was that people located in Zones within the same ring buffer may have similar travel behavior characteristics.

However, this assumption taken may be criticized as it would be more interesting for the researcher to analyse the difference in preferences of the sampled population towards the BRT at a more disaggregate level of Traffic Analysis Zones (TAZ). Though analysis at level of zones would produce more accurate results, it was difficult and impractical to implement as it required more time and resources which was limited to collect more data samples at zone level to produce more statistically efficient results. Therefore, the approach taken of stated choice data analysis at a more aggregate level of the created buffers was thought to be enough and reasonable to provide an insight in preference differences of the sampled population given the limited available resources and for practical reasons.
Also, during stated choice modeling, all the choice responses were first analysed as a whole data set from their respective ring buffers, however the results obtained proved not to produce statistically efficient results. It was thought that this may have been caused by some irrational responses within the data samples as one expected that people would make their choice rationally. Therefore, this made the analyst take a next step of removing irrational choice responses from the data samples with a reason of obtaining statistically efficient results. The irrational choices were deleted and removed from the data samples based on some procedures followed by known researchers. In his stated preference study (Ahern and Tapley, 2007) questionnaire responses were first checked for non-trading behavior and those found were removed and excluded from analysis and secondly the responses were examined for lexicographic behaviour, which occurs when the individual uses only one attribute to determine their choice and those found were also removed and excluded from analysis. It was also stated that responses have been deleted from discrete choice experiments where they have been deemed by researchers to be irrational defined as failing tests for non-satiation or where they represent lexicographic preferences (Lancsar and Louviere, 2006).

Based on the experiences drawn from other researches, therefore in this study the choice responses were checked for non-trading behavior which occurs when the respondent selects the same response option in all replications of the stated choice exercise. Data from this type of response contributes no information about an individual’s sensitivity to different design variables, hence those found were removed from the analysis. Secondly the choice responses were examined for lexicographic behavior which also occurs when the respondent uses only one attribute to determine his choice. Those lexicographic responses found were deleted from the data samples before the analysis.

Although irrational choice responses from the data samples was thought of being the reason for statistically inefficient results and deleting them could be a solution for better statistical results, Lancsar and Louviere (2006) criticizes deleting irrational responses from Discrete Choice Experiments (DCEs). He states that deleting responses from choice experiments may be inappropriate and also may result in the removal of valid preferences; induce sample selection bias; and reduce the statistical efficiency and power of the estimated choice models. He however notes that not all preferences elicited via DCEs are rational, but it may not be the case that all preferences labeled as irrational are indeed so. He further notes that random utility theory may be able to cope with such irrational preferences.

Therefore, having discussed the stated choice modeling approach taken for this section based on analysing preference differences of the commuters in their spatial locations, the next step is to analyse the results and discuss the findings. All the model results are shown and discussed in their respective ring buffers and later the model results from each ring buffer were compared to gain an insight in preference differences of the sampled population in relation to their spatial location differences.
A. Zones Located within 5 km Distance from CBD

Table 6-5: Model Estimation Results for Sampled Population with in 5 km from CBD.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Value</th>
<th>WTP Value</th>
<th>Units</th>
<th>t - test</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>$\beta_{TT}$</td>
<td>-0.0272</td>
<td>18.3</td>
<td>Tsh/min</td>
<td>3.23</td>
<td>0.00</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>$\beta_{FARE}$</td>
<td>-0.00149</td>
<td>-</td>
<td>-</td>
<td>-2.01</td>
<td>0.04</td>
</tr>
<tr>
<td>Comfort</td>
<td>$\beta_{CFT}$</td>
<td>1.11</td>
<td>745</td>
<td>Tsh/unit of CFT</td>
<td>8.26</td>
<td>0.00</td>
</tr>
<tr>
<td>Error term</td>
<td>$\varepsilon_{bn}$</td>
<td>-0.0456</td>
<td>-</td>
<td>-</td>
<td>-0.49</td>
<td>0.62 *</td>
</tr>
</tbody>
</table>

No. of estimated Parameters: 4
No. of observations: 610
Null log-likelihood: -422.127
Init log-likelihood: -422.127
Final log-likelihood: -352.817
Likelihood ratio test: 138.618
Rho-Square $\left( \rho^2 \right)$: 0.164

Utility Parameter Values
All attributes except the mode specific constant have t-statistics greater than 1.96 (more than 95 percent confidence). Overall the model has a likelihood ratio-Index $\rho^2$ of 0.164 when comparing the log likelihood at Zero and the log likelihood at convergence which is slightly lower than the acceptable rho-square range of (0.2 to 0.4) (Louviere et al., 2000).

All the utility parameters have correct signs as shown by the model output Table 6-5 above. Travel Time and Fare have negative signs as expected since an individual’s relative utility will increase when travel time and travel fare decreases and vice-versa. Also one would expect a positive sign associated with comfort as an individual’s relative utility will increase with increase in the level of comfort and otherwise.

Willingness to Pay (WTP) Values
The willingness to pay values for the travel time and comfort attributes are shown in Table 6-5 above. The marginal rate of substitution between travel time and travel fare is given by the ratio of the travel time utility parameter and the travel fare utility parameter (Louviere et al.,…, 2000).

The value of travel time savings for the BRT is 18.3 Tsh per minute. This converts to 1,812 Tsh per person hour and thus tells that a sampled individual is willing to pay, on average, $1,098$ Tsh to save one hour of time spent traveling to CBD holding other potential factors constant. In the same way, a sampled individual is willing to pay $745$ Tsh per unit of comfort ceteris paribus. This tells that, on average a sampled individual is willing to pay 745 Tsh to gain a unit level of comfort. From the results one can also tell that a sampled individual is willing to pay, on average, 40.7 times more to gain a unit level of comfort than to save a unit of travel time.
**Deriving the Utility function**

From the estimated utility parameters, the Total Utility of the BRT for the sampled population located in zones with in 5 km distance from the CBD is given by the following utility expression:

\[ U_{i, BRT}^t = -0.0272_i \beta_{TT}^t + 0.00149_i \beta_{FARE}^t + 1.11_i \beta_{CFT}^t - 0.0456 \]  

(6.3)

**B. Zones Located within (5-10 km) Distance from CBD**

Table 6-6: Model Estimation Results for Sampled Population with in (5-10) km from CBD

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Value</th>
<th>WTP Value</th>
<th>Units</th>
<th>t - test</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>( \beta_{TT} )</td>
<td>-0.0148</td>
<td>4.2</td>
<td>Tsh/min</td>
<td>-2.81</td>
<td>0.01</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>( \beta_{FARE} )</td>
<td>-0.00353</td>
<td>-</td>
<td>-</td>
<td>-5.26</td>
<td>0.00</td>
</tr>
<tr>
<td>Comfort</td>
<td>( \beta_{CFT} )</td>
<td>1.27</td>
<td>360</td>
<td>Tsh/unit of CFT</td>
<td>10.96</td>
<td>0.00</td>
</tr>
<tr>
<td>Error term</td>
<td>( \epsilon_{ln} )</td>
<td>0.0983</td>
<td>-</td>
<td>-</td>
<td>1.56</td>
<td>0.12</td>
</tr>
<tr>
<td>No. of estimated Parameters</td>
<td></td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of observations</td>
<td></td>
<td>1341</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Null log-likelihood</td>
<td></td>
<td>-923.272</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Init log-likelihood</td>
<td></td>
<td>-923.272</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final log-likelihood</td>
<td></td>
<td>-799.266</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Likelihood ratio test</td>
<td></td>
<td>248.012</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rho-Square (( \rho^2 ))</td>
<td></td>
<td><strong>0.134</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Utility Parameter Values**

All attributes and the mode specific constant have t-statistics greater than 1.96 (more than 95 percent confidence). Overall the model has a likelihood ratio-Index \( \rho^2 \) of **0.134** when comparing the log likelihood at Zero and the log likelihood at convergence which is lower than the minimum threshold (0.2) for good model fit.

The signs of all the utility parameters are correct as shown in the model output Table 6-6 above. Travel Time and fare have negative signs except comfort with a positive sign as expected since an individual’s relative utility will increase when travel time and travel fare decreases. Also one would expect a positive sign associated with comfort as an individual’s relative utility will increase with increase in the level of comfort and vice versa.

**Willingness to Pay (WTP) Values**

The value of travel time savings is 4.2Tsh per minute. This converts to 252 Tsh per person hour and thus tells that a sampled individual is willing to pay, on average, **252Tsh** to save one hour of time spent travelling to CBD holding other potential factors constant. Likewise, a sampled individual is willing to pay **360Tsh** per unit of comfort holding other factors constant. This tells that, on average a sampled individual is willing to pay 360 Tsh to gain a unit level of comfort. From the results one can also tell that a sampled individual is willing to pay, on average, 86 times more to gain a unit level of comfort than to save a unit of travel time. The willingness to pay values is shown in table 6-6 above.
**Deriving the Utility function**

The Total Utility of the BRT for the sampled population located in zones with in (5-10) km distance from the CBD, given the estimated Beta parameters is given by the following utility expression:

\[
U_{b2}^{i}_{BRT} = -0.0148_b_{2}TT_{BRT}^{i} - 0.00353_b_{2}FARE_{BRT}^{i} + 1.27_b_{2}CFT_{BRT}^{i} + 0.0983
\]  

(6.4)

**C. Zones Located within (10-15) km Distance from CBD**

Table 6-7: Model Estimation Results for Sampled Population with in (10-15) Km from CBD.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Value</th>
<th>WTP Value</th>
<th>Units</th>
<th>t - test</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>(\beta_{TT})</td>
<td>-0.0343</td>
<td>5.5</td>
<td>Tsh/min</td>
<td>-3.06</td>
<td>0.00</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>(\beta_{FARE})</td>
<td>-0.00623</td>
<td>-</td>
<td>-</td>
<td>-3.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Comfort</td>
<td>(\beta_{CFT})</td>
<td>1.81</td>
<td>291</td>
<td>Tsh/unit of CFT</td>
<td>5.66</td>
<td>0.00</td>
</tr>
<tr>
<td>Error term</td>
<td>(\varepsilon_{b_{2}})</td>
<td>0.146</td>
<td>0.83</td>
<td></td>
<td>0.41*</td>
<td>0.41*</td>
</tr>
</tbody>
</table>

No. of estimated Parameters 4

No. of observations 272

Null log-likelihood \(-188.536\)

Init log-likelihood \(-188.536\)

Final log-likelihood \(-153.549\)

Likelihood ratio test 69.975

Rho-Square (\(\rho^2\)) 0.186

**Utility Parameter Values**

All attributes except the error term have t-statistics greater than 1.96 (more than 95 percent confidence). Overall the model has a likelihood ratio-Index \(\rho^2\) of 0.186 when comparing the log likelihood at Zero and the log likelihood at convergence which is approximately equal to a rho-square of 2 indicating a good model fit.

The signs of the utility parameters are correct as shown in the model output Table 6-7 above. It was expected that a negative sign would be associated with travel time and Travel Fare since an individual’s relative utility will increase when travel time and travel fare decreases and otherwise. Also one expected a positive sign associated with comfort as an individual’s relative utility will increase with increase in the level of comfort and vice versa.

**Willingness to Pay (WTP) Values**

The value of travel time savings for the BRT is 5.5 Tsh per minute. This converts to 330 Tsh per person hour and thus tells that a sampled individual is willing to pay, on average, **330 Tsh** to save one hour of time spent traveling to CBD ceteris paribus. In the same way, a sampled individual is willing to pay **291Tsh** per unit of comfort ceteris paribus. This tells that, on average a sampled individual is
willing to pay 291Tsh to gain a unit level of comfort. From the results one can also tell that a sampled individual is willing to pay, on average, 52.9 times more to gain a unit level of comfort than to save a unit of travel time.

**Deriving the Utility function**

Given the estimated utility parameters (betas), the total utility derived from the BRT attributes by the sampled population located in city zones with in (10-15) km distance from CBD is given by the following utility expression:

\[
U_{b3}^{iBRT} = -0.0343_{b3}TT^{iBRT} - 0.00623_{b3}FARE^{iBRT} + 1.81_{b3}CFT^{iBRT} + 0.146
\]  

(6.5)

**D. Zones Located more than 15 km Distance from CBD**

Table 6-8: Model Estimation Results for Population Located more than 15 km Distance from CBD

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Value</th>
<th>WTP Value</th>
<th>Units</th>
<th>t - test</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>$\beta_{TT}$</td>
<td>-0.0347</td>
<td>8.6</td>
<td>Tsh/min</td>
<td>-6.66</td>
<td>0.00</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>$\beta_{FARE}$</td>
<td>-0.00405</td>
<td>-</td>
<td>-</td>
<td>-4.17</td>
<td>0.00</td>
</tr>
<tr>
<td>Comfort</td>
<td>$\beta_{CFT}$</td>
<td>1.14</td>
<td>282</td>
<td>Tsh/unit of CFT</td>
<td>5.60</td>
<td>0.00</td>
</tr>
<tr>
<td>Error term</td>
<td>$\varepsilon_{bn}$</td>
<td>0.292</td>
<td>-</td>
<td>-</td>
<td>2.86</td>
<td>0.00</td>
</tr>
</tbody>
</table>

No. of estimated Parameters | 4  
No. of observations | 504  
Null log-likelihood | -349.346  
Init log-likelihood | -349.346  
Final log-likelihood | -302.459  
Likelihood ratio test | 93.774  
Rho-Square ($\rho^2$) | **0.134**  

**Utility Parameter Values**

All attributes and the error term have t-statistics greater than 1.96 (more than 95 percent confidence). However, the overall model has a lower likelihood ratio-Index \( \rho^2 \) of **0.134** when comparing the log likelihood at Zero and the log likelihood at convergence.

The signs of all the utility parameters are correct as shown by the model output Table 6-8 above. It was expected that a negative sign would be associated with travel time and Travel Fare since an individual’s relative utility will increase when travel time and travel fare decreases and vice-versa. Also one expected a positive sign associated with comfort as an individual’s relative utility will increase with increase in the level of comfort and otherwise.
**Willingness to Pay (WTP) Values**

The value of travel time savings is 8.6 Tsh per minute. This converts to 516 Tsh per person hour and thus tells that a sampled individual is willing to pay, on average, **516 Tsh** to save one hour of time spent travelling to CBD holding other potential factors constant. Like wise a sampled individual is willing to pay **282Tsh** per unit of comfort holding other factors constant. This tells that, on average a sampled individual is willing to pay 282 Tsh to gain a unit level of comfort. Based on the results one can also tell that a sampled individual is willing to pay, on average, 38 times more to gain a unit level of comfort than to save a unit of travel time.

**Deriving the Utility function**

Since the utility parameters (betas) were estimated, the utility of the BRT by the sampled individuals in zones located more than 15 km distance from the CBD is derived by the following Utility function:

\[
U_{\text{b4}}^{\text{BRT}} = -0.0347\, h_4\, TT_{\text{b4}}^{\text{BRT}} - 0.00405\, h_4\, FARE_{\text{b4}}^{\text{BRT}} + 1.14\, h_4\, CFT_{\text{b4}}^{\text{BRT}} + 0.292
\]  

(6.6)

**6.3.3.3. Comparison of Commuters’ Preferences based on Spatial Location Differences**

Table 6-9 below presents the various Utility models estimated with the collected samples. Three attributes were considered in this analysis in all the five estimated models. Examining all the models in detail, it can be seen that all parameters have correct signs and are in general significant at the 95% level. Thus, all of these attributes have a statistically significant effect on the BRT choice.

The parameter value for travel time attribute is negative and highly significant in all the utility models, reflecting a preference for shorter travel times. Looking at the magnitude of the parameter values for travel time in all the models, it can be noted that commuters from zones located very far from the CBD that is to say in distance of more than 15 km and (10-15) km show high preference for shorter travel times compared to commuters located in zones near the CBD. However, looking at the generalised utility model at city level, in general commuters prefer shorter times to longer travel times while travelling from their residence locations to the CBD which is as expected.

The effect of travel fare is as expected. The fare parameter is negative and highly significant in all the models indicating that commuters prefer cheap travel fares to expensive travel fares, which is intuitive. The relative magnitude of travel fare parameter in all the estimated models indicates that commuters living in the city out skirts are more sensitive to travel fare and thus show high preference for lower travel fares compared to those living in zones located near the CBD. This seems reasonable since most poor people are located in the city outskirts and would not be able to pay expensive fares given the long travel distance they have to make to reach the CBD. Looking at the general model of the city, In general commuters prefer lower travel fares to expensive fares to travel to CBD.
Another interesting aspect is the magnitude and high significance of the comfort attribute. The parameters for comfort in all the estimated models show positive signs as expected. The positive effects on the comfort attribute indicate that commuters prefer travelling in comfortable environment. Further, the larger magnitude of the comfort parameters observed in all the models suggests high preference for travelling in a more comfortable environment than in less comfort situations. This result is not surprising for the case of Dar es Salaam. Given the poor service and travelling environment of the current public transport in the city characterised by uncomfortable, unsafe and overcrowded
ANALYSING COMMUTERS' ATTITUDES TOWARDS THE PROPOSED BUS RAPID TRANSIT SYSTEM

conditions rendered to its customers, high preference for high comfort modes sounds reasonable. Looking at the relative magnitude of the comfort parameters in all the models, there is no major difference in preference of comfort in all zones, however, commuters from zones located with in (10-15) km distance from CBD have shown high preference for comfort compared to other zones. The reason may be because these people have to travel long distance to CBD and thus doing so in a better comfortable environment would be more satisfactory than in less comfort situations and could be likely since more samples in that ring buffer were collected along the Morogoro corridor, the most congested road in the city. Overall commuters prefer comfortable environment during travel.

The error term \( \varepsilon_{bu} \) represents the non-observable part of utility together with any observational errors made by the modeller. In this study it was assumed that there are no alternative modes to the BRT and since there are no alternatives, it simply means there was no mode choice to be made and thus the choice made was only based on the attributes of the BRT. However, only three attributes among others were selected and used in the choice experiments, therefore the error term in these utility models are included to capture the mean effect of other factors unobserved by the analyst which influence choice making. From the results, it is noticed that the error term is statistically significant in three models and statistically insignificant in the remaining two (Values with asterix*). The reasons for the cause of this insignificance of the error term may be that the attributes used in the utility function explain almost all of the choices. Based on findings of his study, however, Hensher (1979) suggests including the error term despite its statistical non significance especially for new alternatives as results produced in such case are closest to reality. Thus in cases where the parameter was not significant, it was maintained as the best estimate available to incorporate the error term.

It is interesting to note that the generalised model at city level has a best model fit with a rho-square of 0.378 which lies within the acceptable minimum range value of 0.2 and maximum range value of 0.4 for the best model fit (Louviere et al., 2000). The reasons for this could be because of the large data sample used in model estimation and secondly could be because of the variations within the individual respondents that have been incorporated into the model. Compared to other estimated models however, it is seen that their likelihood ratio-index \( \rho^2 \) is lower but closer to the acceptable range values, showing fairly good model fits for estimated models based on samples collected in zones within 5 km and (10-15) km distance to CBD and slightly less model fit for the remaining estimated models. The reason that this may have happened is that small data samples were used in modelling as a result of segmenting the whole data set according to the requirement of each model. Secondly, the removal of the irrational choices may also have lead to loss of model fit.

Another aspect of concern that needed investigation was valuation of each of the attributes used so as to obtain variation in the value attached to each one of them. This was done by estimating the willingness to pay (WTP) values discussed earlier in the beginning of this chapter section. There fore, examining the model results in detail, it was found out that in all cases comfort is more valued than travel time and fare and thus has more contribution in the Utility of the BRT. This can be indicated by the willingness to pay (WTP) values for these attributes. While the relative WTP values of these attributes differed in the different model results, it was always the case that people from different spatial locations of the city valued most comfort and Travel time attributes. On the other hand, while travel fare had the expected negative sign and highly significant based on the model results, it was less valued compared to other attributes. This is contrary to what was expected. It was hoped that people
mainly from a developing country would value travel fare more than comfort and travel time. Therefore, given the socio-economic situation of the Dar es Salaam population characterised by mainly poor people like any other city in the developing countries, it was expected that more value would be associated with travel fare compared to other attributes. There are two possible explanations for this: first it may be because of the variation in the level values of the travel fare attribute used i.e. (300, 500 and 700 Tsh) in the choice experiment. This may be seen to commuters less expensive as the current poor public transport (daladala) also charges fare of 300 Tsh one way. Since most people live far usually have to make one or more bus transfers from their locations to reach CBD and each time a transfer is made a commuter has to pay another cost of 300 Tsh ending up some times paying more than the suggested BRT fare attribute levels. Second, given the poor service and uncomfortable travelling environment of the current public transport in the city, high valuation for better comfort modes would not be surprising.

Also from the model results shown in Table 6-9, looking at WTP values in all cases, it is clearly indicated that the value attached to comfort is higher than that for travel time, which simply tells that on average, a sampled individual would be willing to pay more to gain a unit level of comfort than to save a unit of travel time ceteris paribus. For example, a sampled individual from any zone in the study area is willing to pay on average, 47 times more to gain a unit level of comfort than to save a unit of travel time.

Surprisingly, however, the results suggest high valuation for comfort and travel time for the sampled population located in zones near the CBD (with in 5 km to CBD) compared to other sampled commuters from zones located far from the CBD. It was expected that commuters from zones located far from the CBD would highly value travel time and comfort since they have to travel long than commuters located in zones nearby the CBD. The suggested reason could be that people who live in zones with in 5 km from the CBD are mainly government workers highly educated and big business men with relatively high incomes who from their point of view, time is money and comfort is high class. Thus valuing comfort and travel time high for this group of people is tangible.

Another interesting issue noted from the results is that the willingness to pay (WTP) values for comfort decreased with distance of residential location from the CBD. From the Utility models estimated based on spatial location differences, it can be observed that people located in zones nearby the CBD attach more value to comfort and this value decreases as one moves away from the CBD. The explanation for this is that people who mainly live in the city peripherals are poor and thus for these people comfort may be reasonably valued less compared to the high income earners who live closer to the CBD. In general, the sampled population is willing to pay more for comfort than travel time as indicated in all the estimated model results.
6.3.3.4. Model Estimation based on the Socio-Economic differences of the Samples.

**Modeling Approach**

The approach taken to model the stated choice data in this case was done with the main objective of investigating the difference in preferences of the sampled population based on their socio-economic classes. As already cited in literature, the probability of an individual to choose a given option is a function of his socio-economic characteristics and the relative attractiveness of that option (Ortúzar and Willumsen, 1994). Since different individuals may have different socio-economic characteristics which play a great role in influencing their travel choice behaviour, examining their difference in preferences towards the BRT seemed reasonable.

The first approach taken was to enter the income socio-economic variable into the model; however this appeared insignificant and could not give reliable results. The reason for this may be because information on personal income is under or over reported in most cases especially in developing countries and thus using such data in the model may lead to biased results.

The second approach taken was to use the socio-economic classes formed from the collected socio-economic data (refer section 6.2.1). The whole data set was disaggregated into three parts based on the socio-economic classification: low income, middle income and High income classes. The stated choice data associated to each socio-economic class was entered into the model separately and analysed independently. The choice data was used as whole without deleting responses as it was assumed in this case that the choices were stated rationally. The model estimation results were discussed and summarised under each classification and later a comparison of preference differences was made.

**A. Low Income Class**

**Table 6-10: Model Estimation Results for Low Income Class.**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Value</th>
<th>WTP Value</th>
<th>Units</th>
<th>t - test</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>$\beta_{TT}$</td>
<td>-0.0343</td>
<td>21.3</td>
<td>Tsh/minute</td>
<td>-9.15</td>
<td>0.00</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>$\beta_{FARE}$</td>
<td>-0.00161</td>
<td>-</td>
<td>-</td>
<td>-3.57</td>
<td>0.00</td>
</tr>
<tr>
<td>Comfort</td>
<td>$\beta_{CFT}$</td>
<td>0.722</td>
<td>448</td>
<td>Tsh/unit of CFT</td>
<td>9.08</td>
<td>0.00</td>
</tr>
<tr>
<td>Error term</td>
<td>$\epsilon_{bn}$</td>
<td>-0.944</td>
<td>-</td>
<td>-</td>
<td>-15.10</td>
<td>0.00</td>
</tr>
</tbody>
</table>

No. of estimated Parameters, 4
No. of observations, 3834
Null log-likelihood, -1508.288
Init log-likelihood, -1508.288
Final log-likelihood, -1104.036
Likelihood ratio test, 808.505
Rho-Square ($\rho^2$), **0.268**
Utility Parameter Values
All attributes and the error term have t-statistics greater than 1.96 (more than 95 percent confidence). The Overall the model has a likelihood ratio-Index $\rho^2$ of 0.268 when comparing the log likelihood at Zero and the log likelihood at convergence which indicates a good model fit.

The utility parameters as shown in the model output Table 6-9 above have correct signs. It was expected that a negative sign would be associated with travel time and Travel Fare since an individual’s relative utility will increase when travel time and travel fare decreases. Also one expected a positive sign associated with comfort as an individual’s relative utility will increase with increase in the level of comfort and vice-versa.

Willingness to Pay (WTP) Values
The value of travel time savings is 21.3 Tsh per minute. This converts to 1,278 Tsh per person hour and thus tells that a sampled individual is willing to pay, on average, 1,278 Tsh to save one hour of time spent traveling to CBD and likewise, a sampled individual is willing to pay 448Tsh per unit of comfort ceteris paribus. This tells that, on average a sampled individual is willing to pay 448 Tsh to gain a unit level of comfort. From the results one can also tell that a sampled individual is willing to pay, on average, 21 times more to gain a unit level of comfort than to save a unit of travel time.

Deriving the Utility function
Since the utility parameters (betas) were estimated, the utility of the BRT by the Low income (LI) sampled population was derived by the following Utility function:

$$U_{BRTLI} = -0.0343_{LI}TT_{BRT} - 0.00161_{LI}FARE_{BRT} + 0.722_{LI}CFT_{BRT} - 0.944$$ (6.7)

B. Middle Income Class

Table 6-11: Model Estimation Results for Middle Income Class

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Value</th>
<th>WTP Value</th>
<th>Units</th>
<th>t - test</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>$\beta_{TT}$</td>
<td>-0.0120</td>
<td>8.9</td>
<td>Tsh/min</td>
<td>-4.32</td>
<td>0.00</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>$\beta_{FARE}$</td>
<td>-0.00135</td>
<td>-</td>
<td>-</td>
<td>-3.83</td>
<td>0.00</td>
</tr>
<tr>
<td>Comfort</td>
<td>$\beta_{CFT}$</td>
<td>0.592</td>
<td>439</td>
<td>Tsh/unit of CFT</td>
<td>9.94</td>
<td>0.00</td>
</tr>
<tr>
<td>Error term</td>
<td>$\epsilon_{\text{lo}}$</td>
<td>0.0668</td>
<td>-</td>
<td></td>
<td>1.75</td>
<td>0.08</td>
</tr>
</tbody>
</table>

| No. of estimated Parameters | 4 |
| No. of observations         | 1458 |
| Null log-likelihood         | -2109.247 |
| Init log-likelihood         | -2109.247 |
| Final log-likelihood        | -2021.149 |
| Likelihood ratio test       | 176.196 |
| Rho-Square ($\rho^2$)       | 0.042 |
Utility Parameter Values
All attributes have t-statistics greater than 1.96 (more than 95 percent confidence) except the error term which is also still in the acceptable range above t-value of 1.60 based on literature. Overall the model has a low likelihood ratio-Index $\rho^2$ of 0.042 when comparing the log likelihood at Zero and the log likelihood at convergence which is not a good model fit.

The signs of all the utility parameters are correct as shown in the model output Table 6-10 above. One expected a negative sign associated with travel time and Travel Fare since an individual’s relative utility will increase when travel time and travel fare decreases and vice-versa and also a positive sign associated with comfort as an individual’s relative utility will increase with increase in the level of comfort.

Willingness to Pay (WTP) Values
The Willingness to Pay values are shown in Table 6-10 above. The value of travel time savings for the BRT mode is 8.9 Tsh per minute. This converts to 534Tsh. per person hour and thus tells that a sampled individual is willing to pay, on average, 534Tsh to save one hour of time spent travelling to CBD ceteris paribus. Similarly, a sampled individual is willing to pay 439Tsh per unit of comfort ceteris paribus, meaning that on average a sampled individual is willing to pay 439 Tsh to gain a unit level of comfort. From the results one can also tell that on average a sampled individual is willing to pay 49 times more to gain a unit level of comfort than to save a unit of travel time.

Deriving the Utility function
The total utility derived from the BRT attributes given their estimated beta parameters for the middle income (MI) class was given by the utility expression:

$$U_{BRTMI} = -0.0120_{MI} TT_{BRT} - 0.00135_{MI} FARE_{BRT} + 0.592_{MI} CFT_{BRT} + 0.0668$$  (6.8)

C. High Income Class

Table 6-12: Model Estimation Results for High Income Class

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter</th>
<th>Value</th>
<th>WTP Value</th>
<th>Units</th>
<th>t - test</th>
<th>p - value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>$\beta_{TT}$</td>
<td>-0.0760</td>
<td>95</td>
<td>Tsh/min</td>
<td>-1.67</td>
<td>0.10</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>$\beta_{FARE}$</td>
<td>-0.00798</td>
<td>-</td>
<td>-</td>
<td>-0.13</td>
<td>0.50*</td>
</tr>
<tr>
<td>Comfort</td>
<td>$\beta_{CFT}$</td>
<td>0.310</td>
<td>3,885</td>
<td>Tsh/unit of CFT</td>
<td>3.00</td>
<td>0.00</td>
</tr>
<tr>
<td>$\epsilon_{bm}$</td>
<td></td>
<td>0.0582</td>
<td></td>
<td>0.85</td>
<td></td>
<td>0.39*</td>
</tr>
</tbody>
</table>

No. of estimated Parameters 4
No. of observations 864
Null log-likelihood -648.786
Init log-likelihood -648.786
Final log-likelihood -631.553
Likelihood ratio test 34.466
Rho-Square ($\rho^2$) 0.027
Utility Parameter Values

All the utility parameters have correct signs as shown in the model output Table 6-11 above. The Travel time and Travel fare have negative signs as expected since an individual’s relative utility will increase when travel time and travel fare decreases. Also one expected a positive sign associated with comfort as an individual’s relative utility will increase with increase in the level of comfort and otherwise.

However, not all the attributes are significant in this case. The beta parameter for Comfort was very significant at more than 95% level, the travel time is significant at 90% level but still have a t-value greater than 1.6 which is acceptable. The travel fare and the error term were insignificant; their t-values were highly lower than the acceptable thresholds. Like wise, the overall model has a likelihood ratio-Index $\rho^2$ of 0.027 when comparing the log likelihood at Zero and the log likelihood at convergence which indicates a poor model fit.

Willingness to Pay (WTP) Values

The Willingness to Pay Values given in Table 6-11 above show that the value of travel time savings for the BRT is 95 Tsh per minute. This converts to 5700 Tsh per person hour and thus tells that a sampled high income individual is willing to pay, on average, $5700 \text{Tsh}$ to save one hour of time spent travelling to CBD holding other potential factors constant. In the same way, a sampled individual is willing to pay $3885 \text{Tsh}$ per unit of comfort ceteris paribus. This tells that, on average a sampled individual from a high income class is willing to pay 3885 Tsh to gain a unit level of comfort holding other potential factors constant. From the results one can also tell that a sampled individual is willing to pay, on average, 41 times more to gain a unit level of comfort than to save a unit of travel time.

Deriving the Utility function

The total utility derived from the BRT attributes given their estimated beta parameters for the High income (HI) class was given by the following utility expression:

$$U_{BRT\text{HI}} = -0.00760_{\text{HI}} TT_{BRT} - 0.0000798_{\text{HI}} FARE_{BRT} + 0.310_{\text{HI}} CFT_{BRT} + 0.0582 \quad (6.9)$$
6.3.3.5. Comparison of Commuters’ Preferences based on their Socio-Economic Differences

Table 6-13: Comparison of commuters’ preferences based on their socio-economic differences

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Low Income</th>
<th>Middle Income</th>
<th>High Income</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$ Value</td>
<td>t-Value</td>
<td>WTP-Value</td>
</tr>
<tr>
<td>Travel Time</td>
<td>-0.0343</td>
<td>-9.15</td>
<td>21.3 Tsh</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>-0.00161</td>
<td>-3.57</td>
<td>-</td>
</tr>
<tr>
<td>Comfort</td>
<td>0.722</td>
<td>9.08</td>
<td>448 Tsh</td>
</tr>
<tr>
<td>Error Term</td>
<td>-0.944</td>
<td>-15.10</td>
<td>-</td>
</tr>
</tbody>
</table>

$\rho^2$ values: 0.268, 0.042, 0.027

Table 6-13 presents the estimated models for all the socio-economic classes; Low income, Middle Income and High income. As can be seen all the signs of the attribute utility parameters ($\beta$-values) are correct and most of the t-ratios are satisfactory. In few cases where the parameter was not significant in particular for the high income class, it was maintained as the best estimate available to incorporate that variable as also suggested by (Ortúzar et al., 2000).

The reasons for the insignificance of the travel fare attribute for the case of high income people may be that the fare attribute levels used in designing the choice experiment (300 Tsh, 500 Tsh, 700 Tsh) were so cheap to them given their high income status. The second reason may be because most of the high income people incur more expenses in travelling and only paying the proposed fare was meaningless to them. This was usually stated by the high income people at the time of survey. Likewise the non-significance of the error term for the high income model simply means that the attributes used explains all the choices made by this group of people.

Although it is shown that all the attributes in most of the estimated models have correct signs and a statistically significant effect on BRT choice, only the results for low income model show good fitness of the model with a likelihood ratio index of 0.268 lying with in the acceptable thresholds (0.2-0.4). On the other hand the results for the middle and high income show poor model fits. The suggested reason for this poor model fit is; first the small size of the data samples used for these models may have affected the goodness of model fit since the rho square also depends on the sample size.

The negative signs on the travel time and travel fare indicate that commuters from all socio-economic classes prefer shorter travel times and inexpensive travel fares to longer travel times and expensive...
travel fares respectively. The positive sign for the comfort attribute was expected and indicates that commuters from all groups prefer travelling in comfortable environment to less comfort ones. Further, the larger magnitude of the comfort parameters observed in all the models suggests high preference for travelling in a more comfortable environment than in less comfort situations.

It is also observed from Table 6-13 that high income commuters are willing to pay more to save one unit of travel time than for the middle and low income people holding other influencing factors constant. Like wise, the high income commuters are willing to pay 9 and 8.7 times more to gain a unit level of comfort than for the middle and Low income commuters respectively. Comparing the comfort and Travel time attributes in terms of valuation, on average, a sampled individual from a low income class is willing to pay 21 times more to gain a unit level of comfort than to save a unit of travel time. Also, a sampled individual from a middle income class is willing to pay on average 49 times more to gain a unit level of comfort than to save a unit of travel time and like wise a high income sampled individual is willing to pay 41 times to gain a unit level of comfort than to save a unit of travel time. This indicates that the middle income people attach more value to comfort than travel time compared to other income classes. However, in general comfort has more value than travel time for all income groups.

**6.3.3.6. Relative Impacts of the variables to the BRT Utility.**

The parameter effects shown in Table 6-9 and Table 6-13 show mainly the directionality impact of the BRT attributes and their willingness to pay values. However, the relative impacts of the attributes are not directly comparable because of the different ranges of the attributes. One simple approach to assess the relative importance of each attribute is to compute the contribution to utility of each attribute at its average value when the feature represented by the attribute is present in a route (Stinson and Bhat, 2003). For example, the average value of travel time presented to respondents is 25 minutes in ring buffer within 5 km distance from CBD, and the contribution to utility of each additional minute of travel time is \(-0.0272\) from the model of zones within 5km distance from CBD, Table 6-14 below. Thus the average contribution to Utility of travel time is computed as:

\[
25 \times -0.0272 = -0.68 \text{ utils}
\]

Other values are computed similarly. The results of this exercise are shown in table 6-15 below. Therefore, the relative impacts of the attributes to BRT utility will be determined by using the estimated models based on the spatial location differences of the sampled population. The average value of attributes that represent the BRT when it is implemented as presented to respondents during the survey is shown in the table 6-14 below:

**Table 6-14: Average values of the Proposed BRT Attributes**

<table>
<thead>
<tr>
<th>Ring Buffer</th>
<th>Total Travel Time</th>
<th>Comfort level</th>
<th>Fare</th>
</tr>
</thead>
<tbody>
<tr>
<td>With in 5km</td>
<td>25 min</td>
<td>Seat Guarantee</td>
<td>500</td>
</tr>
<tr>
<td>(5-10) km</td>
<td>35 min</td>
<td>Seat Guarantee</td>
<td>500</td>
</tr>
<tr>
<td>(10-15)km</td>
<td>50 min</td>
<td>Seat Guarantee</td>
<td>500</td>
</tr>
<tr>
<td>More than 15 km</td>
<td>70 min</td>
<td>Seat Guarantee</td>
<td>500</td>
</tr>
</tbody>
</table>

**Note:** Seat guarantee was given code = 1 (used to compute comfort in table 6-15)
Table 6-15 : Relative impacts of attributes to Utility of BRT

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter Value</th>
<th>Average value when BRT is present</th>
<th>Average contribution to Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>-0.0272</td>
<td>25</td>
<td>-0.68</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>-0.00149</td>
<td>500</td>
<td>-0.75</td>
</tr>
<tr>
<td>Comfort level</td>
<td>1.11</td>
<td>1</td>
<td>1.11</td>
</tr>
</tbody>
</table>

Model Results based on Samples from Zones within 5 Km Distance from CBD

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter Value</th>
<th>Average value when BRT is present</th>
<th>Average contribution to Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>-0.0148</td>
<td>35</td>
<td>-0.52</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>-0.00353</td>
<td>500</td>
<td>-1.73</td>
</tr>
<tr>
<td>Comfort level</td>
<td>1.27</td>
<td>1</td>
<td>1.27</td>
</tr>
</tbody>
</table>

Model Results based on Samples from Zones within (5-10) Km Distance from CBD

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter Value</th>
<th>Average value when BRT is present</th>
<th>Average contribution to Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>-0.0343</td>
<td>50</td>
<td>-1.72</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>-0.00623</td>
<td>500</td>
<td>-3.12</td>
</tr>
<tr>
<td>Comfort level</td>
<td>1.81</td>
<td>1</td>
<td>1.81</td>
</tr>
</tbody>
</table>

Model Results based on Samples from Zones within (10-15) Km Distance from CBD

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Parameter Value</th>
<th>Average value when BRT is present</th>
<th>Average contribution to Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel Time</td>
<td>-0.0347</td>
<td>70</td>
<td>-2.43</td>
</tr>
<tr>
<td>Travel Fare</td>
<td>-0.00405</td>
<td>500</td>
<td>-2.03</td>
</tr>
<tr>
<td>Comfort level</td>
<td>1.14</td>
<td>1</td>
<td>1.14</td>
</tr>
</tbody>
</table>

From Table 6-15 above, it is indicated that comfort is the most important BRT attribute for the commuters, followed by travel time and travel fare is the least important attribute in commuters’ evaluation of the BRT. However, travel fare was more important than travel time for commuters from zones located more than 15 km distance from CBD. In general, comfort and travel time were more important than travel fare in contribution to utility of the BRT for most of the estimated models.

6.4. Concluding Remarks

This chapter has presented models for evaluating the commuters’ attitudes and preferences towards the DART system and its characteristics. The main purpose of this chapter was to examine commuters’ preferences and willingness to pay for the proposed DART attributes and more importantly to derive the utility functions that will be used to input the commuters’ preferences into the GIS model for spatial assessment of the BRT (DART) and its characteristics.

The Multinomial logit model has been used in estimation of the Utility parameters, with three attributes: Travel time, Travel fare and Comfort. The stated choice modeling has been done based on the spatial location and socio-economic differences of the sampled population.
The results of the effects of the attributes in this study are quite intuitive. It has been observed that in most of the models, all of the attributes have a statistically significant effect on BRT Choice. The high significance of these attributes in the model illustrates that BRT planners should consider these attributes as possible when evaluating the BRT system. However, less number of attributes has been taken in this study, there are other variables that may be influencing the BRT choice as shown by the significance of the error term in some models.

Furthermore, it has been found from the willingness to pay values that comfort is the most valued attribute compared to travel time and travel fare. This has been seen from their relative contribution to utility of the BRT, in order of importance, generally commuters prefer comfort, travel time and travel fare. Therefore, the BRT planners should pay attention to the order of importance of these attributes for effective Planning of the BRT. However, the importance attached to comfort in this study should be taken with care. The presentation of choice sets to respondents that was done in picture format might have affected actual behaviour of the sampled population given that the picture format gave a clear difference in comfort levels for seat guarantee and overcrowded standing in bus. Thus, it would be interesting to carry out a similar study in the same study area in this case without pictured choice sets to verify if the same results would be obtained. However, presentation of choice sets in pictured format is the most appropriate method to use in cases of hypothetical alternatives. Particularly more appropriate for the Dar es Salaam population characterised by low literacy levels which may in fact lead to non-response and variation in the meaning and interpretation of the attributes that would have biased the results.

Next, this chapter has provided a model that can be used to evaluate the effectiveness of the Proposed BRT (DART) system from the demand point of view. Calculating and comparing the DART utilities can help Planners decide where to implement the DART or how to improve the proposed DART attributes. The results suggest that all attributes should be emphasized in the DART Planning. However, the comfort and travel time attributes should be considered a priority.

In addition a comparison of the utility parameters for the components of Travel Time and Comfort illustrates the differences in the value attached to different attributes. This gives the MNL model a very strong policy role by assisting analysts in evaluating the impact of many policies as defined by specific mixes of attributes modelled in the utility expressions.

The next chapter looks at the spatial assessment of the DART System and its characteristics with inputs from commuters’ preferences. The results from stated choice modelling are input into the GIS multimodal network to have an integrated spatial assessment of the DART system using the capability potential of GIS network analysis.
7. Assessing the Proposed DART System based on Commuters’ Preferences

7.1. Introduction

Although in chapter 5, the spatial coverage of the proposed DART System was analysed based on proximity measures of accessibility which provided an indication of the extent to which the proposed service will be distributed in area and population coverage, the measure did not account for the travel behaviour of commuters. Therefore, for more accurate result accessibility measures, commuter travel behaviour analysis was necessary. Hence the commuters’ perceptions and preferences towards the proposed DART System were examined through stated choice modelling in the previous chapter. The stated choice modelling was used importantly to derive the utility attached to the DART attributes and the total utility of the DART service. From stated choice analysis, utility functions were derived and used to estimate the total utility of the DART service gained by an individual commuter of a given residential zone in the study area. Therefore, Utility based accessibility measures using the derived utility functions were employed for spatial analysis of the DART System. Using a scenario-based approach, the derived utility models in stated choice analysis were used and input into the GIS model for spatial assessment of the effectiveness of the DART system.

7.2. Spatial Analysis of DART Using Utility-Based Accessibility Measures

The travel choice behaviour characteristics of the individual commuters were modelled using their stated preferences. Commuters’ stated preferences represented by the derived utility models were input into the GIS Model for spatial analysis. This was done mainly to evaluate spatially the effectiveness of the proposed DART system based on stated preferences of its potential users. Using the derived utility models, Utility-based accessibility measures were employed for evaluation of the DART System. Figure 7-1 below shows the modelling processes taken.

Modelling Approach
The Stated Choice (Utility) Model

The DART utility model is composed of the observable part of utility i.e the DART attribute variables (Travel time, fare and Comfort) and the non-observable part of Utility, the error term with their associated parameters estimated earlier in stated choice analysis chapter 6. The utility associated with each individual DART attribute variable were summed together to get the total Utility where the Utility model was later input into the GIS model to have a spatial evaluation of the DART system. Therefore the total utility of the DART service \( U_{BRTi} \) gained by an individual commuter from a given residential zone \( i \) in the study area was given by the following basic Utility model (refer to eqn.6.1 chapter 6):

\[
U_{BRTbi} = \epsilon_{hn} + \beta_{TTbi} TT_{BRTi} + \beta_{FAREbi} FARE_{BRTi} + \beta_{CFTbi} CFT_{BRTi}
\]

The GIS Multimodal Network Model

The GIS model employed in this study was a multimodal type of Network Model since it comprised of more than one type of Net work. The Multimodal network was made up of:

1. The DART System Network (DART phase 1 corridor Network)
2. The existing public transport (Dala-dala network)
3. The existing road network

These different network types were integrated together to build one multimodal network model in which the Utility model was input using the capability potential of GIS tools that was later used for network analysis. This multimodal Network was a representation of the already existing and proposed transport system of the city of Dar es Salaam. This Multimodal network was adapted from the Network database created by Niels Fikse (Student from Twente University) with who together formed a research team to evaluate the proposed DART system from both the demand and Supply perspectives. The multimodal network was first investigated properly to understand how the network components were built, the network routes and the various assumptions taken in its construction so as to input the Utility model.

Limitations of the Network Model Used

First the Multimodal Network model used only considered the DART phase 1 corridor and did not consider the all six DART phases given that the required information about other phases are not yet in place. Therefore all the analysis and conclusions for DART System in this chapter will be based on the DART phase 1 and its Feeder system. Secondly, the network Model was constructed in such away that the DART System had some competition with the existing public transport (Daladala) on the same routes. However, in this study it was earlier assumed that the DART system will not have any competition from the Daladala. Therefore, to overcome this competition problem, the travel time for daladala routes competing with DART phase1 Network with in a buffer distance of 2000 meters was increased.
**Integrating the Utility-based Model into the GIS-based Network Model**

In integrating the utility model into the GIS model, first the multimodal network was checked whether it had all the required attributes: the travel time, Fare and comfort on each of the network components. The travel time and fare were already attributed to the Network. However, the comfort attribute was not added earlier in the Network. Therefore, the comfort attribute, the Utility of each individual attribute variable and the Total Utility model was entered into the Network and after the network was rebuilt for further analysis. While other attribute variables were simple to measure spatially, the comfort attribute variable was difficult to input into the Network given its qualitative measure. However, given its importance and contribution to total utility of the DART as shown by the utility model in chapter six, it was necessary to model this attribute spatially. In this case the comfort attribute was entered into the Network by writing the following script:

a) For the DART System (DART Phase 1 main Trunk and Feeder Routes):

\[
\text{Dartcft} = 0 \\
\text{a} = [\text{Type}] \\
\text{if a} = \text{“BB” or a} = \text{“FF” then} \\
\text{dartcft} = 1 \\
\text{endif}
\]

Where:
- BB = link Type DART main Trunk
- FF = Link Type DART Feeders
- Dartcft = Dart comfort level

b) For the existing public transport (Daladala):

\[
\text{Dalacft} = 0 \\
\text{a} = [\text{Type}] \\
\text{if a} = \text{“R” then} \\
\text{dalacft} = -1 \\
\text{endif}
\]

Where:
- R = link Type
- Dalacft = Daladala comfort level

**Note:**

The comfort attribute in this study was defined as the level of comfort gained when inside the bus. Therefore in entering the comfort attribute into the GIS Model, the comfort attribute coding used in making choice sets were used. These orthogonal codes used were:
- Comfortable seat guarantee = 1
- Comfortable standing = 0
- Overcrowded Standing = -1

where the DART main trunk and DART Feeder comfort level were represented by code Value = 1 and Daladala comfort level was represented by code value = -1. Therefore it was needed for the model in this way to assign a comfort (1) as long as an individual commuter hits the DART main trunk or Feeder route likewise assign a discomfort (-1) when an individual commuter hits a Dala-dala route during network analysis.
Trip Origin and Destination of an Individual Commuter

In order to analyse the effectiveness of the DART system using utility based accessibility measures, it was necessary to have origin locations of commuters and destination locations. Then it was only possible to estimate the total utility derived from the use of DART to travel from origin zone to destination zone. In this particular case, 50 TAZs (residential Zones) were used as origins and the destination location was the CBD. Therefore, using the GIS network analysis, it was possible to compute the minimum cost route taken by an individual commuter from a residential zone centroid to the closest facility (CBD) and thus the total utility derived from the trip was estimated.

Developing Scenarios for Assessing DART Effect on Utility

For better evaluation of the DART System, it was required to develop scenarios under which one can be able to assess the effect of DART on commuters’ preferences. Therefore, two scenarios were developed: The “Without DART” scenario and “With DART” scenario. The “Without DART” scenario was taken as the base scenario for evaluating the effect of DART.

In developing this base scenario the “Without DART”, it was important to note two things: first it was required to reflect on the formulation of the choice sets during the choice experiment design where the lower limits of the attribute levels used in the choice sets served as a baseline and represented the existing public transport characteristics. Secondly, since this research used unlabeled experiment to collect stated choice data, the derived utility models can also be used in the base scenario. Therefore, the “Without DART” Scenario was created by reducing the quality of DART attributes to a situation similar to the quality of the existing public transport (Daladala) in the study area characterised by overcrowding, longer travel times and unregulated fares among others. Hence during analysis, the “Without DART” scenario was represented by the Daladala route network and the “With DART” scenario was represented by the DART Phase 1 route network.

Assumptions made for the Analysis

In order to make this analysis possible, some assumptions had to be made. First it was assumed that individual commuters from the same residential zone of Origin have homogeneous characteristics thus have same travel choice behaviour. Secondly, an individual commuter behaves rationally in making choice of a route to take from his zone of origin to the CBD which means he/she takes the minimum cost route. Next it was also assumed that all the commuting trips were originating from the residential zones and destinating at the same location, the CBD. It was also assumed that the DART phase 1 and its feeder attributes will be the same for all the six proposed DART phases. Also for both “With DART” and “Without DART” scenarios, commuters can get service only at stops.

7.2.1. Effect of DART on Commuters’ Preferences at a General city level

The effect of DART was analysed using the general Utility model for the total sampled population which was input into the GIS Multimodal Network for spatial analysis. The Total Utility is given by:

\[ U_{BRT}^i = -0.0487TT_{BRT}^i - 0.00161FARE_{BRT}^i + 0.552CFT_{BRT}^i + 1.06 \]
ANALYSING COMMUTERS' ATTITUDES TOWARDS THE PROPOSED BUS RAPID TRANSIT SYSTEM

**Figure 7-2: Effect on Commuters' Preferences based on ‘Without DART’ scenario at city level**

**Figure 7-3: Effect on Commuters' Preferences based on ‘DART’ scenario at city level**
Figure 7-2 shows the Utility differences between zones in the “Without DART” Scenario. The difference in utility simply means the commuter preference differences represented by their respective residential zones. From figure 7-2, the result show that commuters in zones close to the CBD and located along the main trunk roads have relatively higher preferences than those located in peripheral zones of the city. Therefore reasons can be suggested for this utility difference between Zones. The longer travel times, the poor trip comfort, the travel fare may have contributed to the low preferences by the commuters from the peripheral residential zones. In general, however, most zones in the “without DART” scenario show low utility values indicating low preferences towards the service offered. Hence, this tells that in the “without DART” scenario, the service offered is less attractive to commuters in most zones of the study area especially those located away from the CBD.

Figure 7-3 shows the utility differences between Zones in the “DART” scenario. The results show that commuters located in zones where the DART Phase 1 corridor will be implemented have relatively high preference compared to the same zones in the “Without DART” scenario. This can be shown properly by the utility values of zones located along the DART corridor far away from the CBD compared to the same zones in the “Without DART” Scenario. This indicates that the DART attributes are more attractive to commuters in those zones compared to the attributes in the case without DART. However, in the “DART” Scenario commuters from some zones have low preferences meaning that DART attributes are less attractive. Therefore in this case the “DART” Scenario is less preferred compared to the “Without DART” Scenario for the commuters in the same zones. In general commuters from zones located in the DART Phase 1 corridor especially those along the main DART Trunk and far away from the CBD have a considerably higher preference in relation to the same zones in the “without DART” Scenario.

7.2.2. Effect of DART on Commuters’ Preferences based on Location Differences

Even though the general Utility model for the total sampled population used in section 7.2 has given a picture on the effect of DART on commuters’ preferences, it does not give the complete picture of the DART effect on Utility. However, from stated choice analysis (refer section 6.3.3.2 chapter 6), it was revealed that there was difference in preferences between individual commuters based on their spatial locations. Thus, it was required to analyse spatially the effect of DART between zones based on their spatial location differences using the derived Utility models per buffer ring.

The derived utility models were entered into the GIS multimodal network based on their respective buffer rings. The utility models were entered in both the DART phase 1 network and the existing public transport network (daladala) in order to evaluate the DART effect based on the two scenarios: “DART” and “Without DART”.

Table 7-1 shows the derived Utility models based on the spatial differences of zones within their respective buffer rings which were entered into the GIS model for spatial analysis.
Table 7-1: Derived Utility Models from Stated Choice Analysis.

<table>
<thead>
<tr>
<th>BRT (DART) ATTRIBUTES</th>
<th>Buffer Rings</th>
</tr>
</thead>
<tbody>
<tr>
<td>( U_{b1}^{i\text{BRT}} = -0.0272 b_1 TT^{i\text{BRT}} - 0.00149 b_1 FARE^{i\text{BRT}} + 1.11 b_1 CFT^{i\text{BRT}} - 0.0456 )</td>
<td>Buffer Rings</td>
</tr>
<tr>
<td>( U_{b2}^{i\text{BRT}} = -0.0148 b_2 TT^{i\text{BRT}} - 0.00353 b_2 FARE^{i\text{BRT}} + 1.27 b_2 CFT^{i\text{BRT}} + 0.0983 )</td>
<td>Buffer Rings</td>
</tr>
<tr>
<td>( U_{b3}^{i\text{BRT}} = -0.0343 b_3 TT^{i\text{BRT}} - 0.00623 b_3 FARE^{i\text{BRT}} + 1.81 b_3 CFT^{i\text{BRT}} + 0.146 )</td>
<td>Buffer Rings</td>
</tr>
<tr>
<td>( U_{b4}^{i\text{BRT}} = -0.0347 b_4 TT^{i\text{BRT}} - 0.00405 b_4 FARE^{i\text{BRT}} + 1.14 b_4 CFT^{i\text{BRT}} + 0.292 )</td>
<td>Buffer Rings</td>
</tr>
</tbody>
</table>

Where: 
- \( i = \text{Zone1, Zone2, Zone 3, --, --, --, Zone N} \)
- \( b1 = \text{Buffer Ring 1 (Zones with in 0-5 km distance from CBD)} \)
- \( b2 = \text{Buffer Ring 1 (Zones with in 5-10 km distance from CBD)} \)
- \( b3 = \text{Buffer Ring 1 (Zones with in 10-15 km distance from CBD)} \)
- \( b4 = \text{Buffer Ring 1 (Zones with in more than 15 km distance from CBD)} \)

After the utility models in Table 7-1 above were entered into the GIS network models for both scenarios: the “DART” and “without DART”, comparison was made between these two scenarios to examine the differences in preferences of the commuters within same zones. However, only zones with in the same buffer ring can be compared. This is because zones in different buffer rings have different Utility models but Zones within the same buffer ring have same utility model.

However, using Utility Models estimated at a more aggregated level of buffer ring does not represent clearly the specific travel behaviour of the commuters in a particular zone. To get a clear insight in the preference differences, a more disaggregated utility model estimated at the level of zones would be used. Although using a more disaggregated Utility model would have produced more accurate results, this needed a lot of time and resources as it needs more data and also producing 50 utility models corresponding to 50 zones seemed impractical. Thus for practical reasons, Utility models estimated at level of buffer rings were used. This was relatively enough to give an insight in preference differences of the zones in the study area.

Figure 7-4 below shows preference (Utility) differences within different zones by comparing the “DART” and “Without DART scenario”.

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ANALYSING COMMUTERS’ ATTITUDES TOWARDS THE PROPOSED BUS RAPID TRANSIT SYSTEM

MSc Thesis Research
Figure 7-4: Comparison of Zone Preferences based on ‘DART’ and ‘Without DART’ scenario by buffer ring.
From Figure 7-4, it is shown that generally zones with in the “DART” scenario located where the DART phase1 will be implemented have considerably higher utility values compared to the same zones in the “without DART” scenario in all the buffer rings. This simply tells that commuters from zones in “DART” scenario have considerably higher preference compared to the same zones in the “Without DART” scenario. Therefore one can say that the DART attributes are more attractive compared to the “Without DART” Scenario. Hence based on the result, the DART is the more preferred option.

Also from figure 7-4 it is interesting to note that Zones from city peripheries have considerably higher preference in the “DART” scenario compared to the same zones in the “Without DART” scenario. This difference in preference was a result of the attractiveness of the DART attributes. Generally, based on the results the “DART” scenario was more preferred than the “Without DART” scenario.

7.2.3. Zone Preference Difference between ‘DART’ and ‘Without DART’ Scenarios

Figure 7-5 below shows the difference in Utility between the “DART” and “Without DART” Scenarios. This indicates the difference in preferences of individual commuters from a given Zone in the DART scenario and preferences of the same individual commuters from the same zone in the “without DART” Scenario.

From figure 7-5 the results show that commuters from zones where the DART phase1 corridor will be implemented have considerably increased their preferences based on the indicated high utility values with reference to the base scenario. This tells that the DART has a relatively positive effect on
accessibility in areas where it will be implemented. However, for better understanding of the DART effect on commuters’ preferences with reference to the base scenario “Without DART”, a scatter plot showing “DART” Utility values versus “Without DART” Utility values was used, figure 7-6.

From figure 7-6 above, the diagonal line serves as a reference line to assess the change in preferences of zones shown by the blue dots. Zones located above the diagonal line indicate that they have positively increased their preferences as a result of the ‘DART’ with reference to the ‘Without DART’ Scenario. Zones located along the diagonal indicate that there was no effect on preferences even when the DART was introduced. While Zones located below the diagonal Line show that there was a decrease in preferences as a result of the DART in reference to the base scenario. Based on the results, it was found out that 68% of the Zones have increased their preferences, 16 % have neither increased nor decreased in their preferences, also the remaining 16 % of the zones have decreased in their preferences.

**Utility difference between Scenarios based on Residential Zone class**

The total zones considered were 50 in number where 54% were classified as planned, 32% unplanned and 14% mixed use residential zones.

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**Figure 7-6: Scatter plot: Effect of DART on Utility of zone taking (Without DART) as base Scenario**

**Figure 7-7: Zone distribution based on Residential class**
ANALYSING COMMUTERS’ ATTITUDES TOWARDS THE PROPOSED BUS RAPID TRANSIT SYSTEM

Figure 7-8: Utility Difference between Scenarios by Residential Zone class

From Figure 7-8 above, the results show that most planned residential Zones have relatively higher utility in both the DART and Without DART Scenarios compared to the unplanned residential zones. By comparing the utility values of the zones in the “DART” scenario with those of the “Without DART” Scenario, it can be seen that the former is slightly skewed towards higher Utility values and the latter being slightly skewed towards lower utility values for all planned, unplanned and mixed use residential zones. This tells that the DART is more preferred to the “without DART” Scenario. This is indicated by the decrease of zone percentage with lower utility values and increase of zones with higher utility values in the ‘DART’ scenario with reference to the “Without DART” Scenario.

7.3. Concluding Remarks

This chapter was aimed at evaluating the proposed DART system based on commuters’ stated preferences. Integrating the derived utility models into the GIS model, it was possible to model spatially the preferences and to identify the preference differences between Zones. From the results, it was found out that generally the DART is more preferred to the base scenario (Without DART). More interestingly, Zones far away from the CBD have higher preferences for the DART. The findings have shown that 68% of the Residential Zones have increased their preferences in the DART scenario. However the DART had no effect to 16% of the Zones and the remaining 16% have decreased their preferences as a result of DART. The results have also shown that planned residential zones have relatively higher preferences in both scenarios compared to the unplanned residential zones.
8. Conclusions and Recommendations

8.1. Conclusions

In most developing countries, population preferences are rarely taken into account by policy-makers. This need not be the case. There are ways, however, for policy-makers getting closer to popular views. The stated preference approach used in this study has shown its potential in modelling peoples’ attitudes, thus planning and policy-making can be done from peoples’ preferences for more sustainability and meeting the desires of the society under question.

The study examined the perceptions and preferences of commuters towards the proposed DART System and compared the preferences of commuters based on their socio-economic and spatial location differences. Using the Stated Choice and the GIS-based spatial analysis methods, this study reached its goals in (1) identifying the proposed DART system attributes and its spatial coverage (2) examining commuters’ perceptions and preferences towards the proposed DART attributes and (3) assessing the proposed DART System based on commuters’ preferences.

Concerning the Results of the Study

Using proximity measures, accessibility to the proposed DART Service is not such a major problem. Nearly 70% of the total population could be served within 15 minutes walking time to the proposed DART Stops. Although this shows that more population will have access to the DART service, still 30% of population mainly from the city peripheries will have limited access.

The results have also revealed that around 73% of the population in planned residential zones will have more access to the DART service compared to 63% of the population in the unplanned residential zones mostly assumed to be occupied by the low income people. Consequently, the unplanned residential population is more disadvantaged since 37% have to walk more than the acceptable walking time of 15 minutes to get the DART service compared to 27% from planned residential zones.

It is also indicated that nearly 65% of total area is covered by the DART Service within 15 minutes walking time to the DART stops. The results have shown that 47% of the area under planned residential zones is covered by the DART service compared to 32% in unplanned residential zones. Consequently one can say that both planned and unplanned residential zones have limited access to the DART service given the lower area coverage. However, the unplanned residential zones are more disadvantaged.
Although proximity analysis has been used to assess the spatial coverage of the DART service, the method has its limitations. Proximity does not give the right indication about the type and level of service supplied by the transport system. It only checks the walking time taken from the origin of a commuter to the DART stops. For better accessibility results, it is necessary to combine the proximity analysis with other parameters which measure other aspect of accessibility. These include quality of service, consumers’ preferences, equity and infrastructure availability. However, it would be difficult to evaluate the DART system by combining the different accessibility parameters given its hypothetical situation.

From stated choice analysis, however, given all the limits of the econometric modelling applied, results reveal some interesting divergence in preferences of commuters based on their spatial location differences. Moreover, preferences heterogeneity also appears among commuters based on their socio-economic characteristics. In average, however, the variations in the importance of the comfort, travel time and travel fare attributes across the individual commuters based on their spatial location and socio-economic characteristics is rather marginal. The econometric modelling results for the DART attribute variables indicate in order of importance that the sampled population generally prefer:

- travelling in a more comfortable environment
- Lower travel times
- Lower travel fares

The results of the effects of the attributes in this study are quite intuitive. It is found out that generally all of the attributes have a statistically significant effect on DART Choice. The high significance of these attributes in the model illustrates that Transport planners should consider them as possible when evaluating the DART system. However, fewer attributes have been taken in this study, thus more DART attribute variables should be studied to have a more complete evaluation of the effect of DART attributes on commuters’ preferences.

Further more, from the willingness to pay results, it is revealed that comfort is the most valued attribute compared to travel time and travel fare. This has been seen from their relative contribution to utility of the DART. In order of importance, generally commuters prefer comfort, travel time and travel fare. Therefore, Transport planners and policy makers should pay attention to the order of importance of these attributes for effective Planning of the DART System. Interestingly, however, the results suggest that all attributes should be emphasized in the DART Planning but the comfort and travel time attributes should be considered a priority.

However, the importance attached to comfort attribute in this study should be taken with care. The presentation of choice sets at the time of survey was done in picture format and this might have affected the actual behaviour of respondents given that the picture format gave a clear difference in comfort attribute levels. However, presentation of choice sets in pictured format is found to be the most appropriate method to use in cases of hypothetical alternatives, more so in developing countries. Particularly it is found more appropriate and effective for the Dar es Salaam population characterised by low literacy levels. Otherwise, non-pictured formats may in fact have lead to non-response, variation in the meaning and interpretation of the attributes by respondents leading to biased results.
However, it would be interesting to carry out a similar study in the same study area in this case without pictured choice sets to verify if the same results would be obtained.

In addition, a comparison of the utility parameters for the components of Travel Time, fare and Comfort illustrates the differences in the value attached to different attributes. This gives the multinominal logit model a very strong policy role by assisting analysts, researchers and planners in evaluating the impact of many policies as defined by specific mixes of attributes modelled in the utility expressions.

By integrating a behavioural model with a GIS model and using a scenario-based approach while evaluating the effectiveness of proposed DART system, the results have revealed that generally the DART is more preferred to the existing public transport without DART ‘Dala-dala’. More interestingly, Zones located in the city peripheries have indicated higher preferences for the DART. The findings have shown that 68% of the Residential Zones have increased their preferences in favour of the DART. However, 16% of the zones reported neither increase nor decrease by the DART while the remaining 16% have reported decrease in preferences. The results have also indicated that planned residential zones have relatively higher preferences in both ‘DART’ and ‘Without DART’ compared to the unplanned residential zones.

Finally, it is worth mentioning that the DART system is more preferred to the existing public transport (Daladala) by commuters. Only through offering services characterised by better comfort, lower travel times and lower travel fares will the DART system be attractive to its potential users and hence its sustainability.

In conclusion, by integrating a behaviour (utility) model with a GIS model, the study provides a model that can be used to evaluate the effectiveness of new public transport modes or of changing existing ones. Calculating and comparing DART utilities can help transport planners decide where and how to improve the proposed DART service.

**Concerning the Methods taken in the study**

The effect of various policy options for promoting the share of sustainable modes in the urban mobility can be further studied by executing properly designed stated preference experiments. McFadden(1986) reveals that as with any experiment, one can ask if laboratory behaviour is a good predictor of field behaviour. Good experimental technique can remove most obvious sources of incongruity, but only field validation is fully convincing. Therefore, a policy sensitive behavioural model of DART using jointly the revealed and stated preference data would be of immense help in deciding the best policies.

Although stated preference approach allows us to look at the preferences of commuters in hypothetical situations and to make longer-term predications, these forecasts may not always be reliable. Therefore it is useful to combine stated preference models and revealed preference models to allow advantages of each to be maximised and the disadvantages to be minimised. Combining stated preference data with revealed preference data to estimate the benefits of attributes anchors stated
preference data in the real world and to real decisions. However, Ahern and Tapley (2007) states that combining stated preference and revealed preference data must be done with great care as not all stated preference studies can be combined with revealed preference studies.

The use of stated preference surveys to estimate behaviour changes assumes that people are able to accurately predict their responses to a facility improvement or policy change. Frequently, when people are asked if they will change their behaviour in the future, the responses significantly over predict the proportion of people who actually change their behaviour. This problem can be reduced by combining stated preference and revealed preference data if available, although respondents may still not be able to accurately judge what their true actions would be if faced with a real world situation (Hensher et al., 2005; Louviere et al., 2000; Ortúzar and Willumsen, 1994; U.S Department of Transportation, 1999).

8.2. Recommendations

Based on the observations and findings of this study, recommendations are made. The first recommendation is related to DART policy making, the second recommendation is related to the study, which may help to improve the results for further study. The third one is related to improvement suggestions based on accessibility problems identified in the study.

Concerning the DART Policy Making

The high significance of comfort, travel time and travel fare attributes in modal choice decision making of a commuter tells that the DART Agency and Transport Planners should pay more attention and consider these attributes as possible when evaluating the DART system.

Although the study findings suggest that all attributes should be emphasized in the DART Planning, Transport planners and policy makers should give attention to the order of importance of these attributes for effective Planning of the DART System where comfort and travel time attributes should be considered a priority.

Even though, the findings have shown that travel fare attribute is less important compared to comfort and travel time, Planners and Decision makers should handle it with care given its high significance in the model and given the socio-economic characteristics of the Dar es Salaam population where the majority are low income earners.

Even though the findings have shown that DART system is more preferred to the existing public transport (Daladala) by commuters. Only through providing services characterised by better comfort, lower travel times and lower travel fares will the DART system be attractive to its potential users and for its sustainability.
The study provides a model that can be used to integrate the views of the society in planning mainly in evaluating the effectiveness of new public transport modes or of changing existing ones. Computing and comparing DART utilities can help transport planners decide where and how to improve the proposed DART service.

**Concerning the Study**

Proximity measures used in this study does not give the right indication about the type and level of service supplied by the DART system. It only checks the walking time taken from the origin of a commuter to the DART stops. However, for better accessibility results, it is necessary to combine the proximity analysis with other parameters which measure other aspect of accessibility like number of routes per road segment, route density, number of vehicles in different zones, trip frequencies, equity, infrastructure availability and others which should be used to evaluate the spatial coverage in a more complete way. Due to limitation of data available and given the hypothetical situation of DART system, it was not possible to use them in this study. Further research can be done on this in the future.

Stated preference approach allows us to look at the preferences of commuters in hypothetical situations and to make longer-term predications, however for more accurate forecasting results, it is useful to combine stated preference models and revealed preference models which tells the actual choices of commuters and characterises their travel choices so as to anchor stated preference models in the real world and to real decisions. A similar study combining these two approaches and considering more DART attributes is recommended in the future.

The presentation of choice sets at the time of survey was done in picture format. However, the visual format may have affected the actual behaviour of respondents given that the picture format was more attractive but with a clear distinction between the attribute levels especially for the comfort. Therefore, it would be interesting to carry out a similar study in the same study area in this case with non- pictured choice sets to check if the same results would be got.

The GIS model used in this study for evaluating the effectiveness of the DART system was limited to the DART phase1 corridor only given the required data limitations on other phases. Thus, the results from this model was generalised for the whole DART system. For better results and more complete evaluation, another study is recommended in the future which considers all the six DART phases.

**Concerning the Improvement Suggestions**

The population from the city peripheries will have limited access to DART service. So, in order to meet the mobility demand of those areas, DART feeder routes should be planned and extended in a more cost effective manner putting in mind commuters’ preferences i.e. travelling in more comfortable environment, lower travel times and lower travel fares. Extension of new DART routes should be encouraged in areas that have low utility levels and those that do not have any routes.
Despite the increased preferences in favour of DART observed in most zones of the city, the DART phase 1 corridor has no effect on some zones and also some cases it has decreased the preferences of the commuters reflected by the lower utilities of the Zones. Thus, to improve the attractiveness of the DART system in the unsatisfied zones of the city, new DART feeder routes can be planned and extended especially in areas along the north eastern coast of the city with attention of minimising travel times, travel fare and comfortable travel environment. Zones with DART feeder routes but with less preference indicate that DART service is less attractive for commuters in those zones. Thus, for improvement; frequency of the service, DART stops location, transfer points should be checked.
References


Appendix A- Stated Choice Questionnaire

Individual Travel Stated Choice QUESTIONNAIRE FORM (FOMU YA DODOSO)


The information obtained in this survey will be accorded confidential Treatment and will be used for academic purposes only.

Introduction

The purpose of this survey is to investigate Commuter's attitudes and preferences towards a new Bus System in Dar es Salaam to be implemented in 2009. Because it is impossible to interview everybody, we have chosen you. Your help is very important because your answers will assist us in improving the characteristics of the new Bus system that will provide a far better quality service. Thank you for your co-operation.

Survey Information /Tarifa ya Dodoso

Name of Interviewer /Jina la msaili ____________________________
Survey Ward/Kata ya usaili ____________________________
Buffer-Ring /Jina la kanda ____________________________
Date of Interview/Tarehe ya usaili ____________________________
Time/Muda wa usaili ____________________________
ASK Home location of respondent (Ward)/Uliza makazi ya msailiwa ____________________________

If this is not the same as the survey zone: do not carry out the survey/Kama sio mkazi wa eneo hilo usiendelee kufanya mahojiano

ASK Do you go at least twice a week to the city center? /Je, huwa unaenda mjini walau mara mbili kwa juma?________________
If no: do not carry out the survey/kama hapana usifanye mahojiano.
**Part A: Stated Choice Questionnaire/Maswali ya Kipaumbele**

<table>
<thead>
<tr>
<th>Choice Set</th>
<th>Chosen choice set</th>
<th>Would you like to use this bus for daily travel?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chaguo</td>
<td>Ndiyo</td>
</tr>
<tr>
<td>Choice set 1/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Choice set 2/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Choice set 3/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Choice set 4/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Choice set 5/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Choice set 6/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Choice set 7/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Choice set 8/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Choice set 9/9:</td>
<td>A [ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

**Part B: General Information/Taarifa kwa jumla**

1. **Sex/Jinsia**
   Male/Mwanaume [ ] Female/Mwanamke [ ]

2. **What is your age/? Una umri gani?** ___

3. **What is your Employment Status/? Je,umeajiriwa?**
   Employed full-time/Mwajiriwa wa kudumu [ ]
   Employed part-time/Mwajiriwa wa muda [ ]
   Unemployed/Hujaajiriwa [ ]
   Student/Mwanafunzi [ ]
   Retired/Mstaafu [ ]
   Other, specify/Nyinginezo,Eleza _________________

4. **How many days a week do you visit the city center on average/? Kwa wastani unaenda mjini siku ngapi kwa wiki?** ___
5. What is your main trip purpose to visit the city center? /Lengo kuu la safari zako za mjini ni lipi?

Work /Kazi [   ] School /Shule [   ] Business/Biashara [   ]
Other, specify/ Mengineyo,Eleza [   ] ______________

6. Which means of transport do you mostly use? /Mara nyingi unatumia usafiri wa aina ipi?

Daladala/Daladala [   ] Bicycle/Baiskeli [   ]
Walking/Kwa miguu [   ] Own car/Gari binafsi [   ]
Taxi/Texi [   ]
Other, specify/Mengineyo,Eleza ______________

7. How much walking time does it take you to reach the nearest daladala stop? /Inakuchukua muda gani kutembea kutoka nyumbani hadi kituo cha daladala?

0-10 Minutes/0-10 Dakika [   ] 10-20 Minutes/10-20 Dakika [   ]
20-30 Minutes/20-30 Dakika [   ] Over 30 minutes/Zaidi ya dakika 30 [   ]

8. How much time does it take to reach the city center from your home on average? /Kwa wastani inakuchukua muda gani kutoka nyumbani kwako hadi mjini? _____ hours /Masaa or _____ minutes/Dakika

Part C: Socio-economic Information/Taarifa za kiuchumi jamii

9. Do you own any vehicle? /Je,unamiliki gari?

Yes/Ndiyo [   ] No/Hapana [   ]

10. Do you own a house? /Je,unamiliki nyumba?

Yes/Ndiyo [   ] No/Hapana [   ]

If yes, which type of house? /Je, ni nyumba ya aina gani?

Mud house/Nyumba ya matope [   ] Block house /Nyumba ya block [   ]
11. What is your highest education level? /Kiwango chako cha elimu ni kipi?

None/Sijasoma [    ] Primary school/Elimu ya msingi [    ]
Secondary school/Elimu ya sekondari [    ]
College/Elimu ya chuo [    ] University/Elimu ya chuo kikuu [    ]

12. What is your main occupation? /Shughuli yako kuu ni ipi/zipi?

____________________

13. How much is your average monthly income (in Tsh)? /Kwa wastani kipato chako kwa mwezi ni kipi?  __________ Tsh

14. To which socio-economic group do you think you belong? /Unapofikiri upo katika hali ipi ya kiuchumi?

Tajiri (wealthy)[    ] Unajiweza (comfortable) [    ]
Maskini (poor) [    ] Maskini sana (very poor) [    ]

“Thank You for Your kind Co-operation”
Appendix B- Choice Sets (5-10 km distance to CBD)
Choice set 2/9
Choice set 3/9

Nauli: 300 Tsh

Muda kutoka nyumbani hadi kituoni: Dakika 15

Muda wakusafiri: Dakika 35

Usafiri wa kusimama kwa starehe

A

Chagua

Nauli: 300 Tsh

Muda kutoka nyumbani hadi kituoni: Dakika 15

Muda wakusafiri: Dakika 15

Usafiri wa kusimama wenyewe mbanano

B
Choice set 4/9

Option A

- Cost: 700 Tsh
- Travel Time: 0:05
- Travel Time to Destination: 0:25
- Wait Time: 0:05
- Travel Distance: 25 minutes
- Wait Distance: 15 minutes
- Service: Bus
- Frequency: Every 25 minutes
- Availability: Every 15 minutes
- Capacity: 50 passengers

Option B

- Cost: 500 Tsh
- Travel Time: 0:05
- Travel Time to Destination: 0:15
- Wait Time: 0:05
- Travel Distance: 15 minutes
- Wait Distance: 15 minutes
- Service: Bus
- Frequency: Every 15 minutes
- Capacity: 50 passengers
Choice set 5/9

Nauli: 300 Tsh
Muda kutoka nyumbani hadi kituoni: Dakika 25
Usafiri wa kusimama wenyewe mbanano

Nauli: 500 Tsh
Muda kutoka nyumbani hadi kituoni: Dakika 25
Usafiri wa kuka kwa starehe

Chagua
Choice set 6/9

A

Chagua

B
Choice set 7/9
Choice set 8/9

A

B

Chagua
Choice set 9/9

Option A:
- Cost: 500 Tsh
- Travel time: 0:15
- Destination: Dakika 15
- Usafiri wa kusimama kwa starehe

Option B:
- Cost: 700 Tsh
- Travel time: 0:05
- Destination: Dakika 5
- Usafiri wa kukaa kwa starehe

Chagua