EVALUATION OF STANDARD OF PASSENGER BUS SERVICES

SOME ROUTES OF DHAKA CITY

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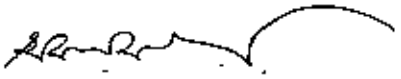

Mohammad Fazle Reza Sumon

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LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
CNG	Compressed Natural Gas
DCC	Dhaka City Corporation
DMP	Dhaka Metropolitan Police
DTCB	Dhaka Transport Coordination Board
EC	Expert Choice
LOS	Level of Service
MV	Motorized Vehicles
MOE	Measure of Effectiveness
MI	Mean Transformation
NMV	Non Motorized Vehicle
PM	Performance Measure
RHD	Roads and Highways Department
RGM	Row Geometric Mean

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ABSTRACT

The need for bus services evaluation standard is universal. Passenger Bus Service evaluation standards are composed of criteria that measure the quality and quantity of services offered by the public transit systems, either individually or group together. Selected criteria cover activities related to bus services and operation, ranging fro location of bus stops to the hours of service. Based on results from the synthesis survey, some transits agencies and operators are formally using standards in the evaluation of bus service systems. This synthesis complies current activity and assesses the state of the art of evaluating individual bus services. Having standards for passenger bus services provides an objective basis for the requisite decisions for sustained operation.

Level of service-quality provided by some improved bus services, namely Premium Bus Service (PBS), BRTC City Service (BCS), Kamaphully CNG City Bus Service, Green Express CNG City Service, Bikolpo CNG City Service, Dhaka Paribahan, Metrolink and Double-Decker VOLVO operating along two different route of Dhaka was comparatively measured in this study through use of a level-of-service or LOS model and pair-wise ranking through Analytic Hierarchy Process (AHP) and the results has been reproduced in this paper. Five performance measures (PMs) (namely, travel time, waiting time, accessibility i.e. load factor, regularity of service and comfort) were selected for the LOS model and six service categories, A through F, with boundary values, were defined for each PM. The defined MOE index for each PM of the selected services for both services route ware measured and judged against the defined LOS categories for the pertinent PM to find its operating LOS score and LOS category. Pair-wise ranking results of the PM's found from the attitude survey results were applied through AHP in order to obtain priority used and standard of the selected passenger bus services.

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Chapter One:

Introduction

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1.1 BACKGROUND AND PRESENT STATE OF THE PROBLEM:

Bangladesh witnessed rapid growth of transport since independence. The overall annual growth rate was nearly 8.2 percent for freight transport and 8.4 percent for passenger transport (Source: Rahman, 2003). Even then the transport intensity of the Bangladesh economy and the level of motorization in Dhaka City is still considerably lower compared to many developing countries. An adequate and efficient transport system is pre-requisite for both initiating and sustaining economic development. The transport system of Bangladesh includes roads, railways, inland waterways, two seaports, maritime shipping and civil aviation catering for both domestic and international traffic. Dhaka, the administrative, commercial and cultural capital of Bangladesh has now been turned into the 26th megacity and 9th most populous city of the world[1]. The quantum of road available for use by passenger transport stands at 2230 km where 650 thousand vehicles, both motorized and non-motorized ply everyday. Dhaka City has 436 km of 4 lane roads, 1408 km of 2 lane roads and 386 km of lanes or by lanes and 220 km of footpath (Rahman, 2003). During the last 34 years, Dhaka City has developed from a neglected provincial capital to a prestigious national capital. The population of the city by this time has increased from 1.2 million to 12 million but the investment required for the urban transport system has not been made[2]. An efficient and standard urban transportation system is essential to cater the travel need of the city's commuters. But the present urban transportation system is overwhelmed with severe problems like congestion, accident, unhygienic, high user cost etc. So it is a prime demand that the city's transportation systems especially the passenger transportation and physical facilities for its operation have to be improved.

Buses will remain the main form of mass transit in Dhaka for many years to come. Bus services in Dhaka City used to be provided only by the private sector before 1961. However they could not meet the growing demand for passenger services. In response to popular demand, the Government took the initiative for satisfying the growing demand of urban transportation in Dhaka City and East Pakistan Transport Corporation (EPTC) was formed in 1961, which later became Bangladesh Road Transport Corporation (BRTC). Passenger Bus Services are operated in Dhaka City by both private and public sectors. The private sector is dominating and providing a

[1] Newspaper captioned "Motorized Vehicles in Dhaka City" from the Daily Inqilab, Internet Edition
[2] Newspaper captioned "The CNG operated Vehicles in Dhaka City" from the Daily Prothom Alo, April 2003

monopoly service (95% of total bus services) compared to the public sector operation. Public Services are operated only by the Bangladesh Road Transport Corporation (BRTC) in Dhaka City involving a total of 255 Double Decker buses and 267 single decker buses carrying 150,000 passengers on average per day, (DUTP, 2003). Whereas the number of total buses in the private sector operation has been estimated as of 2003 in Dhaka at about 2,814 (BRTA, 2004). In Dhaka, around 55% of the total metropolitan area is unserved by buses (Hasan, 2004). The present bus services provide inefficient, unproductive, and unsafe level of services. Long waiting, delay on plying, overloading, discomfort, and long walking distance from the residence/work place to bus stops are some of the major problems that confront the users in their daily life. Responding to the Bangladesh Government's declared deregulated fare policy for improved passenger bus services, some private operators have introduced improved environment friendly passenger bus services of which some have air conditioning facilities and no standing passenger policy on some routes of Dhaka City. However, another private operator taking a few buses from the Government owned organization i.e. BRTC on lease basis has introduced another improved service along with the same route of Motijheel-Uttara and Motijheel-Mirpur. In order to find the standard as well as the quality of service actually provided by these passenger bus services, AHP and a level-of-service or "LOS" model has been followed, adapted and modified from Quium and Tanaboriboon (1994). They used a LOS model, which is mainly operation oriented and could be used by the bus operators/managers to manipulate the service levels through change of operation parameters, if desired.

1.2 CURRENT PASSENGER TRANSPORT MODES IN DHAKA CITY

From the beginning of the history of Dhaka City till today its transport has been composed of different modes, especially road transport modes. These modes can be broadly classified into two categories, the Motorized transport (viz bus, minibus, truck, car, auto-rickshaws, auto-tempo and motorcycle etc) and the Non-Motorized transport in short NMT (viz. rickshaw, rickshaw van, bicycle, and push cart etc.) in Dhaka City is still low compared with other Asian cities (Ahsan, 2003). At present the total number of motorized vehicles is estimated more than 0.28 million (including

registered and non-registered) (BRTA, 2003). This study is mainly concerned motorized transport especially on passenger bus services.

There have been significant recent developments in the passenger bus services and systems in Dhaka City including increases in bus numbers, more high quality buses and a shift to cleaner buses and more organized operations.

There have been several noteworthy changes in the public transport fleet composition since early 2003. All types of passenger buses, minibuses and large buses have increased substantially and two-stroke auto rickshaws have been removed to avoid environmental degradation.

Probably the most significant change in the bus fleet composition in the last 24-months is the rapid increase in the number of large buses. This trend began with Sino-Dipon Bus Service in early 2003. Sino-Dipon Bus Service is now operating on six routes by different service namely Transilva BD Services. Karnaphully CNG City Service with 135 buses. Green Express began operations in April 2004 with 35 buses: currently they have 50 buses in operation on two routes and will shortly bring in an additional 50 buses. BEVCO, a company formed apparently by a non-government organization with North American funding are in operation with 20 large air-conditioned buses. Dhaka Paribahan, a major minibus operator in Dhaka has recently imported 10 large improved dedicated CNG buses from China, which will likely be used to replace existing minibuses. Green Way City Service Limited and Bikalpa CNG City Service, two other reputed minibus companies began operations in the end of 2004 with 35 and 10 buses respectively and will shortly bring additional 25numbers and 10 numbers respectively.

CONCEPT OF IMPROVED LARGE BUS AND MINIBUSES SERVICES

Improved large buses are defined according to regulations as buses with more than 32 seats, but in this research they are defined as buses 10 meters or more in length. The large buses, which are so called improved buses have shown considerable dynamism in Dhaka in recent years, despite generally poor operating conditions caused by

increasing congestion. As of August 2004, there were 2,974 bus and minibus permits issued for operation on 59 routes in Dhaka. though officials reported that only 26 routes were actually operational. However these figures do not include

- The combined fleet of Nirapad, Roadster and Metro bus services
- Beveo's fleet of 20 buses
- BRTC's fleet of 306 buses
- 50 buses of the Green Express fleet and recent addition to some other fleets.
- An estimated 1,600 minibuses operating in the city without permits
- An estimated 600 suburban buses operating in the city.

The BRTC, which operate under immunity from regulation by licensing authorities; own a total of 522 buses operating on 15 routes in Dhaka City. Of these 255 are double- decker buses (older Ashok Leyland and Volvo) and the remainder are standard 10-12 meter single-decker buses. BRTC does not operate these buses but sub contracts them out the operations to private operators. The number of permits issued does not necessarily reflect the number of buses actually operating. However, based on the findings from the secondary sources, the large bus fleet in operation in the urban routes of Dhaka City is estimated to consist around 500 buses.

Minibuses are defined as buses with 15 to 32 seats capacity, excluding the driver. Most minibuses are around 8 meter in length with locally manufactured bodies on Isuzu. Hino or Tata chassis and engines.

1.3 OBJECTIVES

The main objective of the study is to make an investigation on existing passenger bus service system and to measure the quality of service as well as standard provided by the selected transit mode. To achieve the main goal, specific objectives have been accepted, which shows as under.

1. To weigh up the existing passenger bus services at the selected routes.
2. To appraise the level of service of some selected passenger bus services

The present study has been limited to examining the performance standard of the passenger bus services, the actual demand of bus users and opinion of the passengers and operators. Study on the total performance standard of passenger buses was not possible as this requires huge information on commuting speed, space required by buses to run in normal standard speed, designing of buses in such a way that a minimum number of people can board and disembark in the shortest possible time, effective parking systems and constructing road to accommodate more vehicles. This research was also been limited to selected bus services on specific route. Especially, five passenger bus services including improved air-conditioned, CNG operated and conventional minibuses were taken into consideration.

In this study, service performance and their standard of single-decker air-conditioned and CNG operated, double-decker and minibuses were compared for some selected service attributes namely performance measures (PM). In examining the user demand, all aspects could not be studied. The users' demand was examined by means of surveying the load on buses in peak and off-peak periods and queuing of passengers at the bus stops.

With the limited available data, the research was done by evaluating the selected performance measures as standard and due to time and resources constraints, this study was limited to service and operational performance of selected passenger bus services instead of economical aspect and cost performance.

1.4 ORGANIZATION OF THE STUDY

This study has been organized in a systematic way in eight chapters. Chapter one introduces the background of the study, current passenger transport modes in Dhaka City, objectives of the study, scope and limitations of the study. In the second chapter, a comprehensive literature review has been presented where some measures and model and relevant studies on standard evaluation have been focused. Chapter three contains detailed methodology of this research where some models and measure of standard evaluation have been described in detail. The required data and possible source of bus transport services in the past and present have been listed in chapter four

and the pattern of passenger bus services are also illustrated in this chapter. In the next two chapters, the investigation and identification of passenger bus services related to standard and other system deficiencies are analyzed according to the collected data and information from the field survey. In the chapter seven, application of some model through acquired data and information is the main focus.

Standard of passenger bus services were measured and judged against the defined LOS categories for the pertinent PM with the boundary values. The LOS scores were then combined together through applying weights of the corresponding PMs derived from AHP and found from the attitude survey results. In this chapter, a proposal has been given to implement improved passenger bus services on the study route including a package of policy options.

Chapter Two:

Literature Review

2.1 MEASURES AND MODELS OF TRANSIT PERFORMANCE

Many researchers and investigators addressed various theoretical and methodological issues and developed alternative methodologies for performance evaluation. They were primarily concentrated on developing concepts and models in order to identify the actual measures or indicators of performance evaluation. The concept of performance evaluation and the development of performance indicators were first conceived by Tomazinis (1975). He proposed transit productivity to be measured from four points of view namely operator, user, society and government.

Fielding and Glauthier (1976) are credited with developing a conceptual model for selecting performance concepts and indicators and developing a methodology for performance evaluation.

The use of level of service (LOS) concept in public transportation is relatively of recent origin. Though Botzow (1974) is recognized for first applying the LOS concept to assess the quality of public transit systems. He considered some variables to measure the quality of service, which were speed, delay and comfort factors associated with the vehicles including density, acceleration, jerk, temperature, airflow and noise. He also adopted the conventional six levels of service categories (A through F) and then defined the boundary values for each level of the selected factors. Weightings of selected factors and variable in terms of points were determined on the basis of an opinion survey. Level of service boundary values in terms of variables were then related to points assigned for that particular variable. To determine the overall measure for a selected bus service, the level of service categories were determined against each variable and then their corresponding assigned points were summed up to obtain the aggregate score.

The LOS concept as an evaluation tool for assessing the quality of service has been used successfully in the context of highways since the first introduction of the highway capacity manual about 40 years ago. Quium (1993) mentioned the names of several researchers whose works extended the application of LOS concept to transit performance evaluation.

After (1976) formulated a different model following Botzow (1974) and using those variables related to service generation and operation and excluding variables related to facility or equipment standard. For the justification of his selection, he theorized that quality measures could be considered in two broad categories, which are hygiene factors and LOS indicators. He finalized six LOS indicators, i.e. accessibility, travel time, reliability, directness of service, frequency of service and passenger density. He also proposed a five-point grading scale and weighted sum method for the indicators to determine a boundary score.

Later on, Khisty (1989) developed a LOS model using similar variables as used by After (1976), adding two variables, viz-individual cost and public information and addressed new clarification for the selected variables. He followed two new approaches, first, for measuring certain indicators, viz. frequency and passenger comfort. He depended on passenger's opinion through a survey rather than using a parameter representing the variables. Secondly, he made the score aggregation methodology more scientific by adopting the nonparametric statistical tool of constant-sum-paired comparison method.

Quium and Tanaboriboon (1994) developed a new LOS model considering all the preceding works and forwarded four indicators or performance measures to evaluate the quality of service for transit performance evaluation. The four selected performance measures namely travel time, waiting time, load factor and regularity of services are usually common concern of the bus passengers, reflecting demand aspects of bus services. They executed this model in evaluating the quality of service of 14 selected bus routes of Bangkok Mass Transit Authority (BMTA) in Bangkok, Thailand. The developed LOS model was considered to be operations oriented so that the bus managers could manipulate the level of service through operational changes, if desired. The developed LOS evaluation methodology provided a tool for evaluating bus services and had scope of applications for other prospective purpose, such as planning for the improvement of bus-service quality

An in-depth investigation was made to evaluate the performance of Premium Bus Service by Das (1998), where he followed Quium and Tanaboriboon's LOS model using five performance measures. Those measures were selected primarily due to their policy sensitivity and operator controllability. The adapted model included one more variable, the in-vehicle comfort, or simply comfort, whereas the Quium and Tanaboriboon model used four Performance Measures (PMs).

For the level of service evaluation for the passenger buses in the present study, "weighted sum method", which involves taking cumulative weighted points of the individual indicators, will be used.

2.2 SOME RELEVANT STUDIES ON PERFORMANCE EVALUATION ON PASSENGER BUS SERVICES

Relevant studies and literature have been reviewed to get more ideas, explanations, theories and models to achieve its objectives and techniques available for evaluating the overall service and operational performance of selected bus services. Besides, a review of few exemplary studies in performance evaluation has also been presented. It will also describe recent practice and trend of improvement of overall performance of passenger bus service. Hence an extensive literature survey of the documents on the relevant researches, reports, books, articles, proceedings etc. has been performed.

Bangladesh Transport Survey (1977), in particular describes the operational, financial and management aspects of most modes especially bus transport at city, district, regional and national levels

Fielding and Anderson (1983), used a conceptual model to select a few performance concepts for transit performance evaluation. Data were obtained from a national sample of 311 urban bus transit systems in the first year and date were reported under Section 15 of the Urban Mass Transportation Act of 1965, as amended. The steps in the performance evaluation procedure involved defining a conceptual model of

performance and designing a balanced set of performance indicators that represent all performance concepts. Factor analysis was then used to select the indicators that best represent all dimensions of performance.

This small representative set of performance indicators was used to analyze performance and to establish peer-group ranking. The derived indicators along with their definitions are sown in the following table.

No	Factor	Performance Indicator Chosen to Represent the Factor
1	Output Cost	Revenue vehicle hours per operating expenses (RVH/OEXP)
2	Service Utilization	Total passenger per revenue vehicle mile (TPAS/RVM)
3	Vehicle Efficiency	Total vehicles miles per peak vehicle (TVM/PVEH)
4	Fuel Efficiency	Total vehicle miles per gallon of fuel consumed (TVM/FUEL)
5	Public Assistance	Passenger revenue per operating assistance (REV/OSUB)
6	Social Effectiveness	Revenue vehicle hours per urban population (RVH/POP)
7	Maintenance Efficiency	Total vehicle miles per maintenance employee (TVM/MNT)
8	Revenue Generation/ Expenses	Passenger revenue per operating expenses (REV/OEXP)
9	Safety	Revenue vehicle hours per accident (RVH/ACC)

Source: Fielding and Anderson (1984)

Firdus (1984) in his study on the problems of bus transport in Dhaka City investigated some important but common transportation services related problems with respect to bus mode like long travel time, delay and overloading and thus low level of service.

Wright and Thirie/ (1987). developed a method of transit performance evaluation applicable to reasonably well-managed bus companies in developing countries. The stated performance indicators and their suggested ranges of recommended values are shown in the following table. The World bank method is a crude, but simple transit-performance evaluation procedure which can provide a quick, comprehensive idea about the performance status of the bus service being evaluated. However, the set standard of bus services was meant to be attainable by developing countries.

Table: 2.1 Performance Indicators for Bus Companies in Developing Countries

No	Performance indicator		Range
1	Passenger carried per day	Minibus	600-800
		Single-Decker Bus	1000-1200
		Double-Decker bus	1500-1800
2	Kilometers per bus per day		210-260
3	Kilometers per bus per hour		0.3-0.4
4	Staff employed per bus	Administrative	0.5-1.5
		Maintenance	3-8
		Total	
5	Accidents per 1000000 bus kilometers		1.5-3.0
6	Fleet availability and fleet utilization		80%-90%
7	Fuel consumption: Litres per bus per 100 km	Minibus	20-25
		Single Decker Bus	25-40
		Double-Decker bus	40-50
8	Operating ratio (revenue divided by total operating cost)		1.05.1 - 1.08:1

Source: Wright and Thiriez (1987)

Tanaboriboon et. al. (1992), demonstrated that the performance indicator analysis technique could be successfully used as a diagnostic tool to identify operational efficiency and ineffectiveness at the route level of transit operation. In this research, the derived technique was applied on 14 bus routes of Bangkok Mass Transit Authority to reveal the inter-route differences in operational efficiency and effectiveness. Results of the analysis revealed that considerable variations existed across the routes against many of the selected indicators. These included variations in terms of labor and capacity utilization, maintenance expenditure etc. many of which could be improved through suitable managerial measures. Based on these findings, specific recommendations were made for improvement in the deficient areas that were considered to be within the operator domain. These indicators also provided a basis for comparison over time with other operators with standards. A ranking scale was also developed to determine the overall attractiveness of the routes.

The Greater Dhaka metropolitan Area Integrated Transport Study (DITS) conducted with UNDP assistance between 1992 to 1994 was conceived as a multidimensional and integrated study of bus transport services in Greater Dhaka. The study recommended realistic and affordable short-term actions to improve the passenger bus transport services in Greater Dhaka. The study also developed a local capability to analyze and recommends long-term policies and programs responding to transport services as required as urban areas grow and mature.

Das (1998) studied the different aspects of evaluation models and theories and developed some measures of effectiveness of some performance measures to identify the service level and economic assessment approach of Premium Bus Services and BRTC City Services. He also demonstrated the combination of performance indicators termed as performance measure (PMs) analysis to identify the service level efficiency and effectiveness as well as to evaluate the bus transport services.

UNESCAP (2002) noted that public transport systems in much of the ESCAP reason were predominantly used by lower income groups. With few expectations, services are overcrowded and irregular. A major problem for passengers is the large gap between ground level and the doorways of public transport vehicles. The problems that commonly are seen in public transport systems in the escape region include user intensive planning, inadequate investment, poor management, inadequate revenue (due partly to revenue leakage), poor maintenance and deterioration of services. At the same time, users demands continue to grow simply because most low-income users have no alternative. The study revealed that there is an enormous potential growth market for public transportation in Asia and Pacific. Buses account for 90 percent of public transport movement in the world. In the ESCAP region, daily bus passengers constitute a significant portion of the total population using public transport. Moreover, buses have a low investment and fare cost advantage over other modes of public transportation. A recent ESCAP survey of the integration of non-motorized transport in the urban transport system of Dhaka revealed that the cost in passenger/km of bus is a quarter of that of auto rickshaw and under half that of

rickshaw. The study suggested gradual replacement of improved buses over their estimated average service life of 12-15 years.

Ahsan, 2001, set out to assess the existing transportation system in Dhaka City and developed policy approaches that could mitigate environmental pollution, minimize traffic congestion and ensure mobility for different income groups. The transportation system needs to ensure mobility affordable to all income groups, convenient and of course environmental friendly to be a sustainable transportation system. The researcher had identified that due to traffic congestion, the total economic loss of Dhaka is about US$ 570 million per year. He noted that the loss is too high as about half of the city dwellers live under the poverty line. He concluded that environmental friendly modern and sophisticated high capacity improved bus services need to be introduced to meet the public transport demand and to ensure mobility for all income groups.

Chapter Three:

Methodology

3.1 INTRODUCTION

Methodology is the guidelines and logical framework for the researcher for conducting the research. To fulfill the objectives effectively and to carry out the entire study, some procedures and initiatives have been undertaken

3.2 CONCEPT OF THE LOS MODEL

The level of service is an overall measure of almost all service elements that affect the bus users Evaluation of the service levels of the Metro Bus Service (Premium A/C), BRTC City Service, Karnaphully City Service, Dhaka Paribahan, Mega City CNG Service, Green Express CNG Service and Double Decker VOLVO Service was carried out with the following concepts and procedures.

Measure of effectiveness (MOE) is defined as a parameter that best describes the quality of certain operating characteristics. LOS performance measure (PM) is a combination of selected indicators or MOEs. A group of PMs is carefully selected for this research work in order to fulfill the objective of evaluation of service levels of the improved passenger bus services. Levels or categories of services of these selected PMs are then defined. Having defined the service levels, boundary values of the MOEs for each level of service are established by considering available standards, passengers' attitude, etc. The measured MOE index value for each PM is judged against the corresponding defined service categories in order to find the actual operating service level, or LOS category and LOS score provided. The LOS scores thus obtained against individual PMs are then combined together through an aggregation method to obtain overall LOS score (and LOS category) for the selected bus service. Rationality of selecting the PMs and the LOS evaluation procedure are elaborated below.

LOS involves two types of parameters. The first type is the operational performance that includes travel time, waiting time, level of occupancy and regularity of service or reliability. The second type is the transportation hygiene factors involving riding

comfort, cleanliness, crew behaviour, noise, protection against environmental elements, etc. Riding comfort is concerned with the make and design of the vehicle and is very difficult to define and measure. Indeed, it is pertinent to very sophisticated cars and not to public vehicles in the Third World countries. Protection against environmental elements is not adequate for any bus service, which is almost in the same poor status and need not be evaluated in any comparative study.

However, in-vehicle comfort is a factor of prime interest to most of users of improved bus services. Although in-vehicle comfort is generally affected by so many factors, for the sake of convenience and simplicity, it is defined in this research to be contributed by five major elements, namely cleanliness, crowdedness, temperature, noise and crew behaviour. It is apparent that if these five components are kept in favourable conditions, in-vehicle comfort is ensured. Thus, a group of five PMs, namely travel time, waiting time, load factor, regularity of service and comfort are selected for the LOS model. Six levels or categories of service, A through F, are considered for the five selected PMs. These levels are then measured on an equal interval 6-point scale, with the highest point of 5 for level A and 0 point for level F. The assigned points for the other levels are 4 for B, 3 for C, 2 for D, and 1 for E. Boundary values for these six service levels (MOEs) are established considering available standards, passengers' attitude and rationality.

The PM comfort, a synthetic variable according to the definition, is assessed through evaluation of its five elements, namely cleanliness, crowdiness, temperature, noise and crew behaviour through the passengers' attitude survey.

The required parameter values are measured from field surveys and data obtained from Premium Bus Services, Green Express CNG Services, Metrolink, Mega City CNG Services and Double-Decker Volvo operators on the Motijheel-Uttara route and Bokilpo City Service, BRTC Single Decker, Karnaphully CNG City Service, Dhaka Paribahan and Double-Decker Volvo operators on the Motijheel-Mirpur route and other related sources. The results of a passengers' attitude survey are applied to define the six service levels for the two PMs, namely travel time and waiting time. The

The service levels of the three other PMs, namely load factor, regularity of service and comfort are defined considering physical standards and rationality.

The LOS category of a PM is determined by comparing its actual value or the value of its MOE with the established service levels. An aggregation methodology (namely, weighted-sum) is followed to combine the separate LOS categories against the selected PMs. A weighting system (use of AHP to consolidate weightages assigned to individual PMs by the respondents of attitude survey) is also followed to reflect the relative significance of the selected PMs. The aggregated LOS category give the overall service quality provided by a bus service.

3.3 MEASUREMENT INDICATORS OF SERVICE QUALITY

3.3.1 Definition and Measurement of MOE Indices of the PM's

Travel Time

Results of passengers' attitude survey are used in defining the six service levels of the travel time PM as well as in measuring its MOEs. Mini bus service is chosen for comparison, because of its widespread usage in all routes of the city. MOE index for this PM is defined as the ratio of the difference between travel times of selected bus services and minibus service, plying on the same route. Selected bus service passengers are asked about their expectations of relative travel times by five-bus services in two defined routes and the mini bus service operating on the same routes. In particular, passengers are asked about their opinions regarding how faster (or slower) the selected bus service compared to a conventional mini bus would be acceptable to them. A wide range of options about the acceptable level of relative speed for the five bus services compared to a minibus in percentage is given to the passengers for selection according to their expectation. A graph of speed of selected improved bus service, relative to minibus service, vs. cumulative percentage of passengers who mentioned the choice, is drawn for interpolation of the relative speed

against a particular percentage of passengers. Acceptable levels of MOE to defined minimum percentages of passengers are applied as the criteria to establish boundaries of the six service levels for the travel time PM. The LOS category distribution for this PM is thus formed.

Waiting Time

Standard of bus service i.e. service quality is closely concerned with the extent of waiting time. There exists many methods, both direct and indirect, to measure or estimate passengers' waiting times. But several investigators reported that collecting data on actual waiting times is not a feasible proposition mainly due to the reason that a huge number of bus stops might have to be surveyed. Secondly, as the same stop may be used by several bus routes, it is difficult to conduct such a survey due to passenger identification problems. Hence, waiting time in this research work was estimated by an indirect method applicable for randomly arriving passengers. The following empirical formula given by Bowman and Turnquist (1981) is applied.

$$w = h/2\,(1 + cv^2\,(h)) \quad \ldots \quad (1)$$

where,

w = mean passenger waiting time,

h = mean headway, and

$cv(h)$ = coefficient of variation of headway.

The headway data are collected for the selected five-bus service in two defined route and the mean passenger waiting times are calculated from there. The calculated mean passenger-waiting time is taken as the MOE index for the waiting time PM

Results of passengers' attitude survey are employed in defining the six service levels of the waiting time PM. Passengers' are asked about the maximum waiting times acceptable to them with few options. The reported acceptable maximum waiting times are plotted against cumulative percentage of passengers who choose the options with a view to interpolate acceptable maximum waiting time for any particular percentage of

passengers. Based upon the findings about the acceptable levels of waiting times, the required boundary values for the six service categories, A through F, are established. In case of travel time, acceptable levels of MOE to defined minimum percentages of passengers are applied as the criteria to establish the boundaries of the six service levels. The LOS categories are thus established for the waiting time PM.

Load Factor

Passenger comfort is greatly concerned with the load factor, which can be measured directly from the level of loading or actual physical space occupying. Considering a greater tolerance limit of the people of the developing countries, it would not be appropriate to compare available space on-board with any western standard. Moreover, according to survey conducted, the adopted standard to determine legal capacities of buses in Dhaka is even lower than the standards adopted for Bangkok (by Quium and Tanaboriboon, 1994) which is a Third World city. However, load factor compared to legal capacity is taken as the MOE for this PM and legal capacity of buses for Dhaka is estimated according to on-board survey conducted and from the survey findings of previous studies. The legal capacity of buses related to a standard based on number of seats plus 6 passengers per square meter for the standees are arbitrarily defined as the C level. The lower limit for the F level is defined based on "crush-load" limit of 12 passengers per square meter space for the standees. Other levels are established in relation to these defined levels. Ultimately the LOS categories are determined considering standards adopted for Bangkok and results of bus-occupancy survey actually administered for Dhaka.

Regularity of Service

Regularity of service of a particular transport largely determines its reliability. It affects both passenger waiting time and level of occupancy. Irregularity of service not only decreases reliability but also deteriorates quality of service. Service regularity may be assessed based on the indirect measurement of excess waiting time due to irregular service. The following empirical relationship developed by Henderson, et al (1991) to calculate a passenger waiting index based on the original formula put

forward by Bowman and Turnquist (1981) was used for indirect measurement of regularity of service in this research.

$$W = 1/(1 + cv^2(h)) \quad \ldots (2)$$

where,

W = proportion of the average waiting greater than the minimum average waiting

$cv(h)$ = coefficient of variation of headway.

Reciprocal of W indicates how longer is the estimated waiting time than the waiting time when services are perfectly regular. For example, if W is 0.6, it would imply that the estimated waiting time is 1/0.6 or 1.667 times longer than the waiting of a perfectly regular service. W can be expressed in a scale of 0 to 1, where the value "1" indicates a perfectly regular service. In this research, equation (2) is used to estimate passenger- waiting index as a measure to assess the regularity of the selected ten bus service in two defined route.

Reciprocal of W is taken as the MOE index for the Regularity of Service PM. The six service levels and their boundary values are determined based on rationality, keeping in mind the possible range of W and acceptable maximum limit of $1/W$ as observed by previous researchers (e.g. Quium and Tanaboriboon, 1994). Thus the LOS category distribution for the Regularity of Service PM is constructed.

Comfort

In-vehicle comfort or simply comfort is a major factor in attracting travelers to use improved bus services. This PM, comfort is defined to be consisting of five constituent elements, namely cleanliness, crowdedness, temperature, noise and crew behaviour. Each of these elements is placed before the passengers for evaluation on a 6-point scale (0 to 5) where 0 indicated the least acceptance or the worst performance and 5 indicated extreme acceptance or excellent performance. Individual acceptability/ performance index for each element is then calculated for all respondents with help of the following equation.

$$I_u = \sum (s_i f_i)/N \qquad \ldots (3)$$

where,

I_u = Index of acceptability for service attribute u,

f_i = frequency of respondents giving rating i to service attribute u.

s_i = scale value of the rating i,

N = Summation of frequencies of respondents giving lowest to highest rating = $\sum f_i$

MOE index for the comfort PM took to be the geometric mean of the index values for the five constituent elements of comfort. Geometric mean is using, because the index values are conventionally interpreted as pertinent percentages (e.g.. an index value of 0.8724 is interpreted as virtual 88.24% of the sample), and the type of mean used for percentages is 'geometric'. This mean-value would give some indication of overall acceptability of the service attribute comfort as a whole, in terms of acceptability of existing performance to that percentage of users (respondents) as given by the MOE index value.

The values of the MOE index thus obtained must lie between 0 to 1.0. This span is divided into six groups, simply based on rationality. to define and form boundary values of the six service levels.

3.3.2 Determination of Relative Importance of the PM'S

Determination of relative importance or weights of the selected PMs are essential for combining the individual LOS categories against the PMs. The technique of Analytic Hierarchy Process (AHP) (Anon, 1992) is employed for this purpose. AHP was developed by Thomas L. Satty in 1977 mostly to help find out hierarchy of different items in an analytic process. To apply the AHP technique in determining priorities or relative importance of competing items, a model of the hierarchical relationships is first prepared. In an AHP model. there would be one a goal; several nodes under the goal; several sub-nodes under all or some of the nodes; etc. The nodes. sub-nodes, etc. are taken in all possible number of pairs during the calculation or compilation of the program, and both local and global priorities can be determined from the AHP model on computer.

In order to determine relative importance of the five selected PMs, a simple AHP model was prepared with five nodes (five PMs) under the goal of "Determination of relative importance of PMs". Pair-wise relative importance of the PMs, as obtained from each passengers' response in the attitude survey, was input to the program, and overall relative importance of the PMs assigned by each passenger (respondent) were separately obtained by running the program. However, judgment of some respondents were discarded which, on being fed into the AHP model, produced an inconsistency ratio beyond a defined limit (3.0). Having thus obtained relative importance of the PMs for individual respondents' responses, average overall weightage for each PM was determined by taking average of all the 'valid' individual respondents' assigned weightages. The actual determination of relative importance of the five selected PMs will be presented in later discussion.

3.3.3 Aggregation of LOS Score against Individual PM'S

The aggregate overall levels of service standard of the selected bus service on the particular route was determined from the LOS categories against each of the five PMs by employing the assigned points for each category (0 to 5) and the weighting factors found from the survey results. To calculate the overall LOS, the points for an operating LOS against a PM were multiplied by its weighting factor. Summation of the five weighted points provided the overall LOS score.

3.4 ANALYTIC HIERARCHY PROCESS (AHP)

The Analytic Hierarchy Process (AHP) is a mathematical technique for multicriteria decision-making (Saaty 1980, 1990, 1994). This Model was designed by T. L. Saaty as a decision making aid, which enables people to make decisions involving many kinds of concerns including planning, setting priorities, selecting the best among a number of alternatives, and allocating resources.

AHP is especially suitable for complex decisions, which involve the comparison of decision elements, which are difficult to quantify. It is based on the assumption that

when faced with a complex decision the natural human reaction is to cluster the decision elements according to their common characteristics.

It involves building a hierarchy (Ranking) of decision elements and then making comparisons between each possible pair in each cluster (as a matrix). This gives a weighting for each element within a cluster (or level of the hierarchy) and also a consistency ratio (useful for checking the consistency of the data).

This study conducted AHP in three steps:

1. Perform pair-wise comparisons
2. Assess consistency of pair-wise judgments
3. Compute the relative weights

01) Pair-Wise Comparisons

AHP enables a person to make pair-wise comparisons of importance between decision elements with respect to the scale shown in the following Table.

Table-5.3. AHP Scale for the pair-wise comparisons

Intensity of Importance	Definition	Explanation
0	Equally important	Two decision elements (e.g., indicators) equally influence the parent decision element
1	Slightly important	One decision element is slightly more influential than the other.
2	Moderately important	One decision element has stronger influence than the other.
3	More important	One decision element has significantly influence over the other.

4	Much more important	One decision element has significantly more influence over the other.
5	Extremely	The difference between influences of the two decision elements is extremely significant.

An excerpt of the questionnaire is given in appendix one.

02) Assessing Consistency of Pair-Wise Judgments

In pair-wise comparison of any alternatives, the matter of inconsistency makes the results confusing. In AHP, before computing the weights based on pair-wise judgments, the degree of inconsistency is measured by the Inconsistency Index. Perfect consistency implies a value of zero. However, perfect consistency cannot be demanded since, as human beings, we are often biased and inconsistent in our subjective judgments. Therefore, it is considered acceptable if inconsistent value is $\leq$ 0.1. For the values greater than 0.1, the pair-wise judgments may be revised before the weights are computed.

03) Computing the Relative Weights

AHP computes a weight for each decision element based on the pair-wise comparisons using mathematical techniques such as Eigenvalue, Mean Transformation (MT), or Row Geometric Mean (RGM). This study implies the Eigenvalue technique for computing the weights under AHP and hence expert choice 11 software used for assessing the weight of the selected alternatives i.e passenger bus services.

3.5 PASSENGER BUS SERVICE STANDARD EVALUATION CONCEPT

Performance evaluation (operation performance and economic assessment) is a multidimensional concept that embraces all or some of the performance measures: efficiency, effectiveness and social impact. There are numerous criteria used in the performance measures of bus services evaluation process. In and of themselves, these criteria initially serve as indicators that gauge the quality and quantity of service offered by a passenger bus services system. They also include a number of items that determine as well as reflect the manner in which bus transit systems offer standard services to the public and are often directly related to the cost of service provision. This conceptual framework of this study divides the bus service evaluation standard into three broad categories.

3.5.1 Economics and Productivity Standard

Economic and productivity standards include criteria that measure the performance of an already existing passenger bus service. The criteria are as follows.

- Passenger per hour
- Cost per passenger
- Passenger per mile
- Passenger per trip
- Passenger miles
- Revenue per passenger per mile and route
- Route level minimum cost
- Route level performance relative to other routes

3.5.2 Service Delivery Standard

The criteria for this category of standards measure the reliability and regularity of services. Service delivery criteria include ontime performance and headway adherence. This criteria measure a performance standard of service as actually delivered to a passenger.

3.5.3 Passenger Comfort and Safety Standards

This category is called service quality and the bus service evaluation standard criterion for passenger comfort and safety measures the overall physical environment, which a passenger will encounter on board. Passenger comfort and safety are defined to be consisting of five constituent elements namely cleanliness, crowdedness, temperature, noise and crew behaviour.

3.6 DETERMINATION OF ACCEPTABILITY OF SERVICE ATTRIBUTES

Selected quantitative indicators with regard to some performance measure can evaluate passenger bus service standard. Five performance measure reflecting service standard of passenger bus services are selected to evaluate the quality of service and standard of 10 selected bus services in two bus routes. The five selected measures termed service attributes are travel time, waiting time, load factor, regularity of service and comfort are usually the common concern of bus passengers. To accomplish the objective of standard evaluation, a level-of-service quality or LOS model has been used.

3.7 ASSUMPTION IN THE STUDY

Some assumptions were made for the identification of performance measure. Assumptions were made based on some standard and method set forth by others researchers.

3.8 WORKING PROCEDURE FOR COLLECTION OF DATA AND ANALYSIS

Data and information from both primary and secondary sources were used for this study. For primary data collection, personal interview according to the pre-designed questionnaire was undertaken. Data were collected regarding service standard, travel pattern, modal choice behaviour, and also collected socio-economic characteristics of an individual trip maker, trip information and service attributes of the selected passenger bus services. The following section explains the detail the data collection process.

3.8.1 Literature Survey and Collection of Data from Secondary Sources

An extensive literature survey relevant to this subject and other passenger transport services was carried out to acquire background knowledge about the service standard and system performance of passenger bus services (in terms of efficiency and effectiveness) and level of service (LOS), measurement techniques and model and to develop a theoretical design for evaluating passenger bus service standard presentation.

Due to the nature of the topic, substantial data and information were required, which were collected from government/semi-government organizations and other transport service providers. An extensive literature survey was undertaken and information was collected from a number of published and unpublished studies both from inside and outside the country. Other than the literature survey, a considerable amount of time was spent in gathering information from different organizations, which are directly and indirectly engaged in public transportation.

3.8.2 Selection of Passenger Bus Services and Route for this Study

Two routes i.e. Motijheel-Uttara route and Motijheel-Mirpur route were identified for this study. Ten bus services, five of each route namely Premium Bus Services, Green Express CNG Services, Metrolink, Mega City CNG Services and Double-Decker Volvo on the Motijheel-Uttara route and Bokilpo City Service, BRTC Single Decker, Karnaphully CNG City Service, Dhaka Paribahan and Double-Decker Volvo on the Motijheel-Mirpur route have been selected for the comparison.

3.8.3 Sample Number and Sampling Strategy

Questionnaire survey was undertaken for the fulfillment of this study where an individual was chosen as a sampling unit. Due to limitation of time and money, a reliable size of sample could not be chosen. A sample of 800 individuals was taken for collecting travel data on the two-selected routes. As the sample was quite small, the

results would tend to be indicative of travel behaviour in the passenger bus services rather than definitive.

In discrete choice analysis there are three ways to extract the sampling from the population. These are random sampling, stratified sampling and cluster sampling as stated by Chen et. al.(1995). In this study random sampling technique was used. Those who do not travel much on passenger bus service or who have made trip only by private cars and taxicabs were kept out of the sample size.

3.8.4 Design of Questionnaire

A passenger/individual opinion survey was undertaken by means of a structured questionnaire, which was designed and distinctively divided into four parts for example socio-economic characteristics, trip related information, passenger travel behaviors or pattern and paired rankings.

An extensive multiple-choice questionnaire has been prepared to obtain information for this study on current activity and data with regards to passenger bus services evaluation standard. To incorporate the people's understanding in identifying passenger bus services and standard, a passenger attitude survey through a questionnaire has been carried out and samples are drawn to reveal the passengers' opinion regarding existing selected passenger bus services and to know about the acceptability indices in terms of cleanliness, crowdedness, temperature, noise and crew behaviour. Physical and observation survey have also been administered and data is collected from the record of selected passenger bus service operators.

3.8.5 Expert Opinion

A comprehensive investigation was accomplished to explore the passenger bus service standard and the perception of many official and transport experts working on transportation issues. Information concerned with their activities and studies on transportation matter were collected. The organizations consulted are listed below:

- Dhaka City Corporation (DCC)

- Roads and Highways Department (RHD)
- Bangladesh Road Transport Authority (BRTA)
- Bangladesh Road Transport Corporation (BRTC)
- Dhaka Transport Coordination Board (DTCB)
- Traffic Division of Dhaka Metropolitan Police (DMP)

3.8.6 Analysis of the Collected Data

The collected data was edited and tabulated as per requirement using various statistical processes including modern computer software. The descriptive and unstructured materials, observations, surveys, documents, maps and other records were summarized and presented in a sequential order in both tabular and graphical format with necessary illustration. The result of the analysis has also been arranged and presented in figures and maps according to necessity.

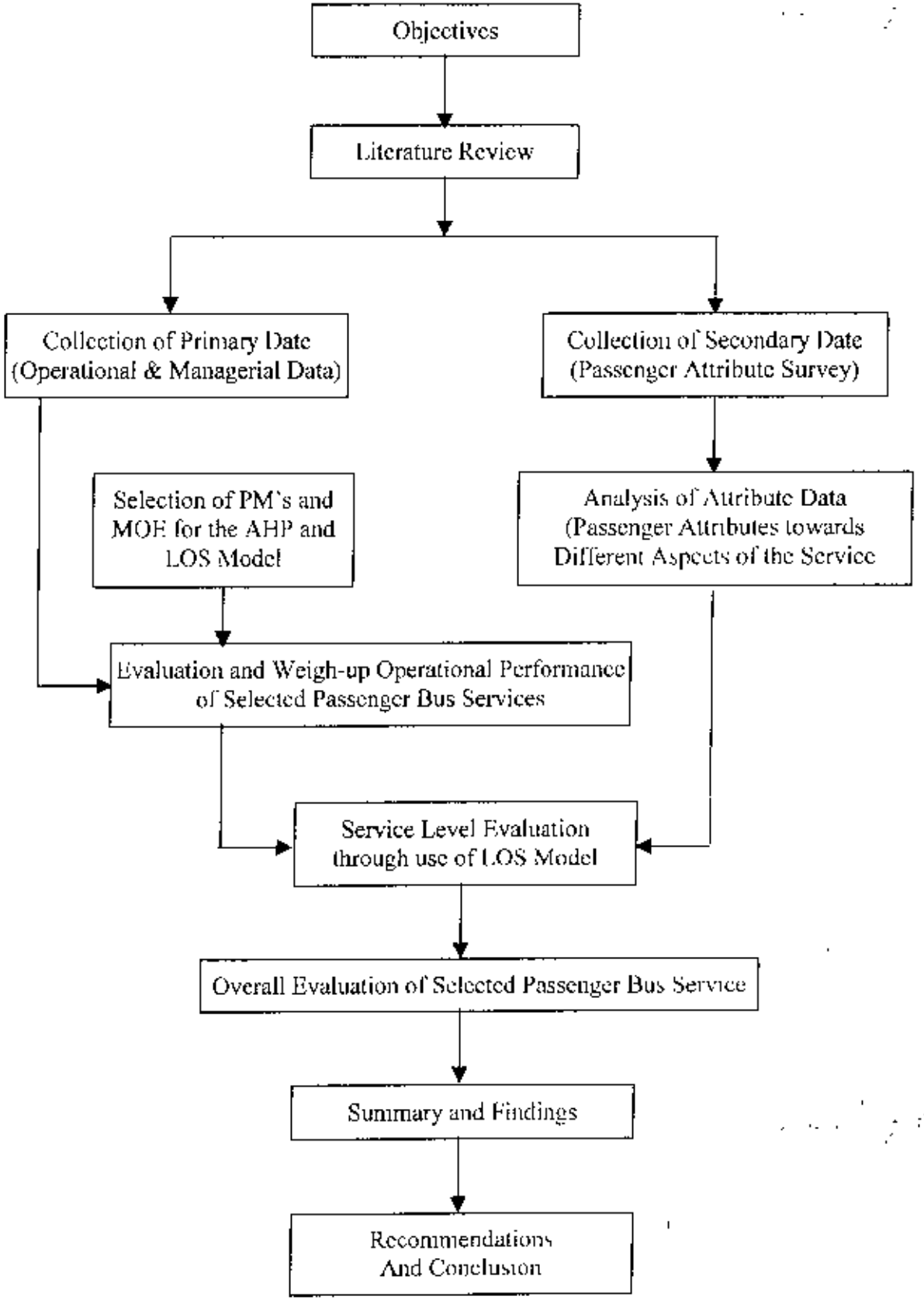
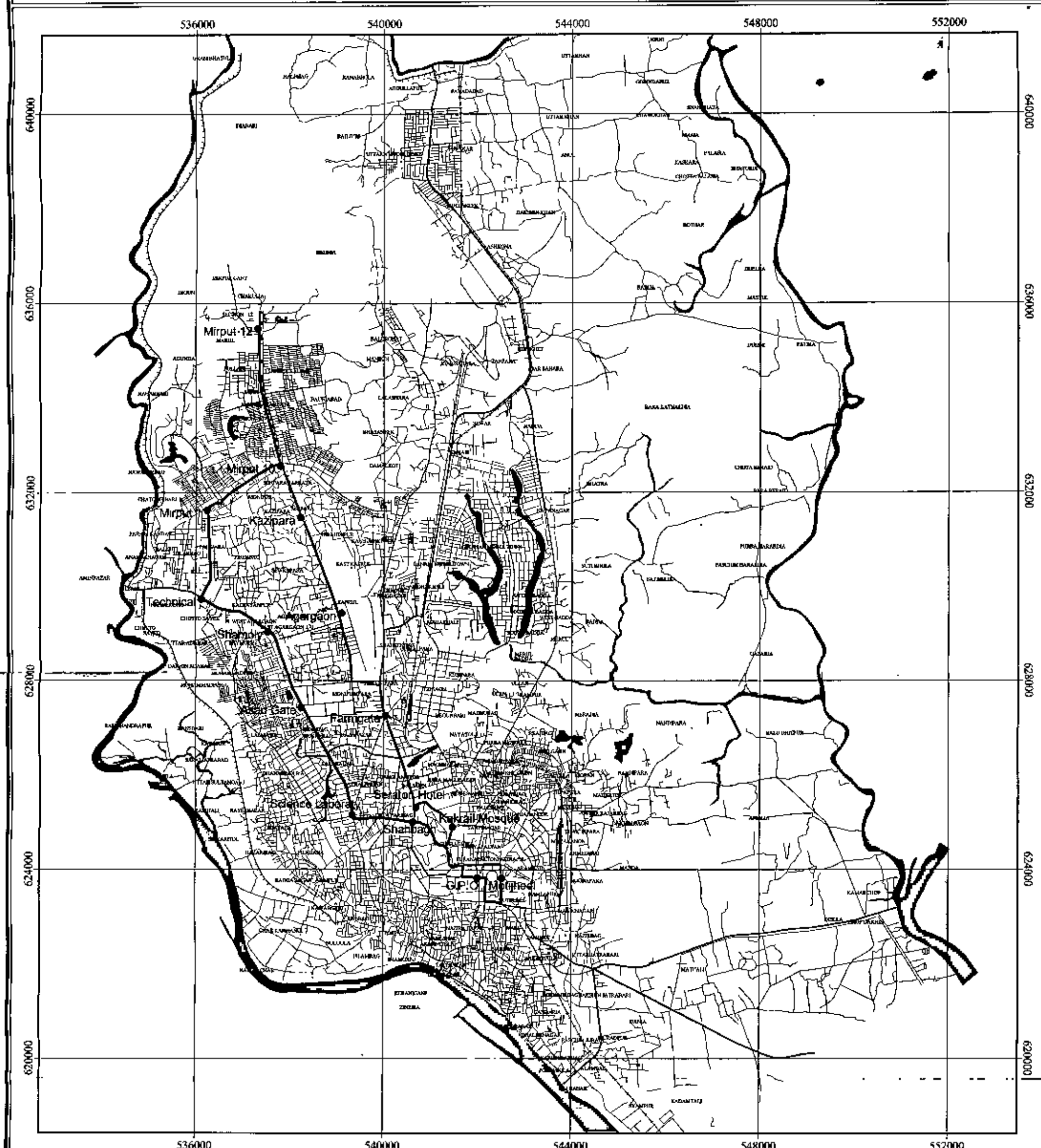


Figure 3.1: Flow Diagram of the Working Procedure of the Study

Map of Dhaka City showing Motijheel to Mirpur Route



Map History

Data Source

Road data collected from Dhaka City Corporation,
Route data collected from field survey 2004

Bangladesh Transverse Mercator (BTM) Projection

Projection	Transverse	Parameters	
Units	Meters	Scale Factor	0.9996
Spheroid	Everest	Central Meridian	90
		Reference Latitude	0
		False Easting	500000
		False Northing	-2000000

Prepared by:

Md. Fazle Reza Sumon

MURP Student # 040015020F

April 2005

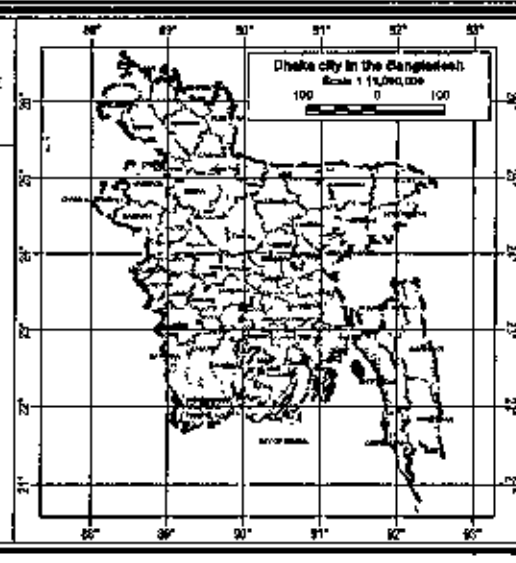
Map Scale 1:80,000

1 0 1 2 3 4 5 6 Kilometers

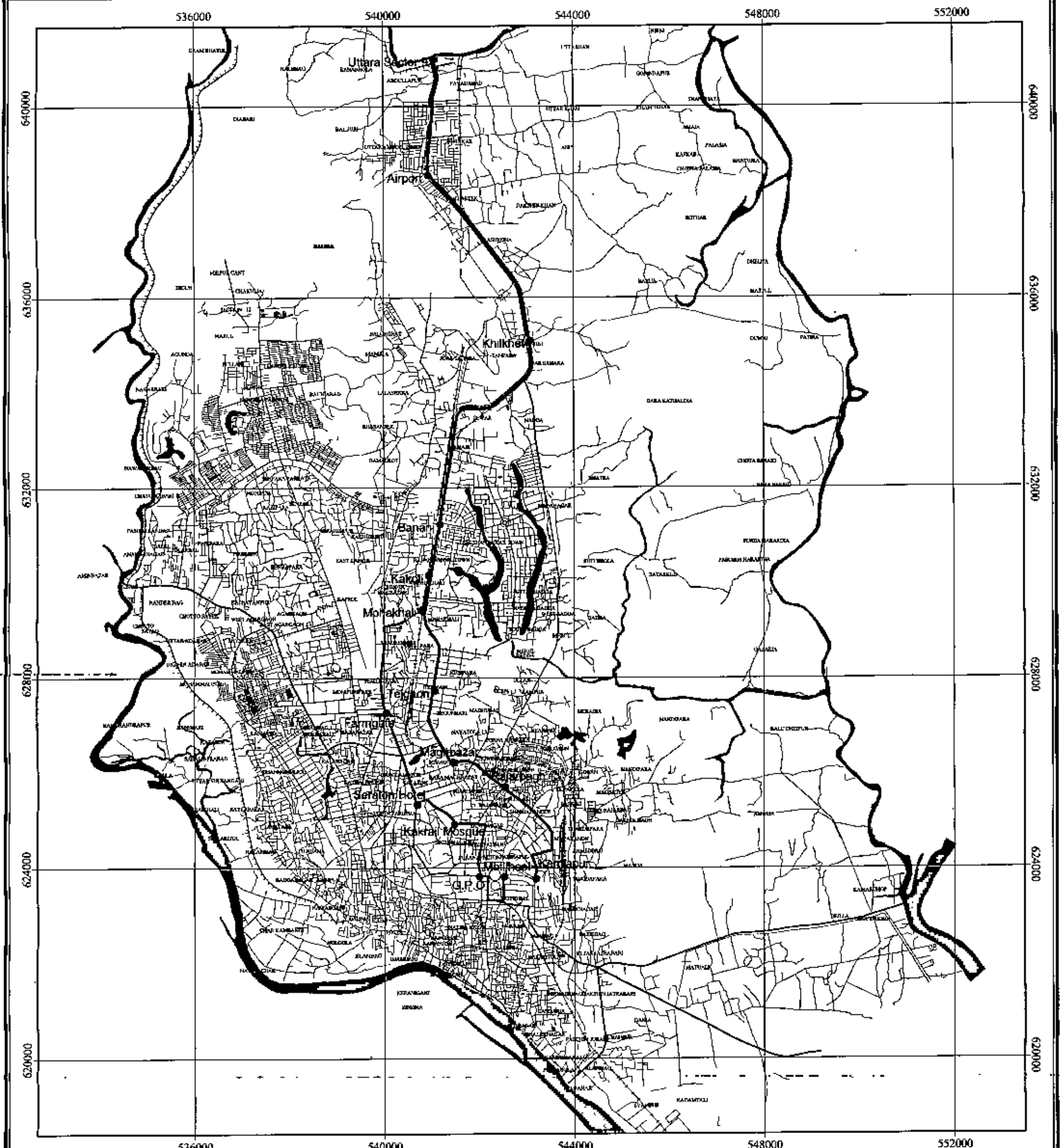
N W E S

Legend

- Route of Motijheel to Mirpur 12 via Shahbagh, Science-Lab & Asadgate
- Route of Motijheel to Mirpur 12 via Sheraton Hotel, Farmgate & Agargaon
- Bus Stop
- Waterbodies
- Embankment
- FARMGATE Name of place
- Collector Road
- Local Road
- Major Road
- Railway



Map of Dhaka City showing Motijheel to Uttara Route



Map History

Data Source

Road data collected from Dhaka City Corporation,
Route data collected from field survey 2004

Bangladesh Transverse Mercator (BTM) Projection

Projection	Transverse	Parameters	
Units	Meters	Scale Factor	0.9996
Spheroid	Everest	Central Meridian	90
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April 2005

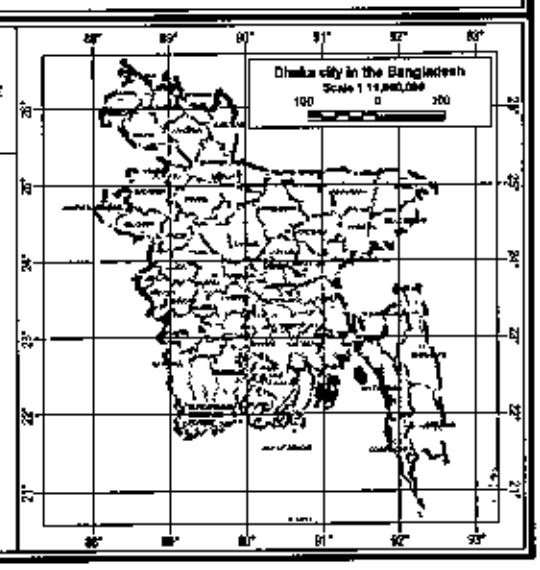
Map Scale 1:80,000

1 0 1 2 3 4 5 6 Kilometers

N W E S

Legend

- Route of Motijheel to Uttara via Razarbagh, Moghbazar & Tejgaon
- Route of Motijheel to Uttara via via Sheraton Hotel, Farmgate & Mohakhali
- Bus Stop
- Waterbodies
- Embankment
- Name of place
- Collector Road
- Local Road
- Major Road
- Railway



Chapter Four:

Passenger Bus Services In Dhaka City

4.1 BACKGROUND OF PASSENGER TRANSPORT SERVICES IN DHAKA CITY

Passenger transport services in Dhaka City are provided by various modes and are characterized by high growth rates, its diversity and poor financial and operational performance. Demand for urban passenger transport services is already enormous and growing at a rapid rate due to rapid rise of population in the city. This has given to paratransit or intermediate public transport modes such as bicycles, tricycles i.e. rickshaws, auto-rickshaws, human haulers, minibuses and large buses. Though personal motorized vehicle ownership continue to rise, walking and passenger bus transport remain the major travel modes.

With increasing city size and area, trip length is increasing and the burden of commuter travel will increasingly fall upon the public transport sector, as longer trips will tend to discourage walking and cycling as convenient alternatives.

The vast majority of the city population will still be relying on road-based transport system for many years to come. With the low levels of car ownership that exists in Dhaka city and with the growing demand for passenger transport, the existing mobility conditions are detrimental to economic well being of the community. The inadequacy of the present systems and its inefficient operation resulting accidents, congestion, overloading and low levels of service, which are mainly attributed to such factors as lack of standard buses inadequacy of roads and insufficient funds.

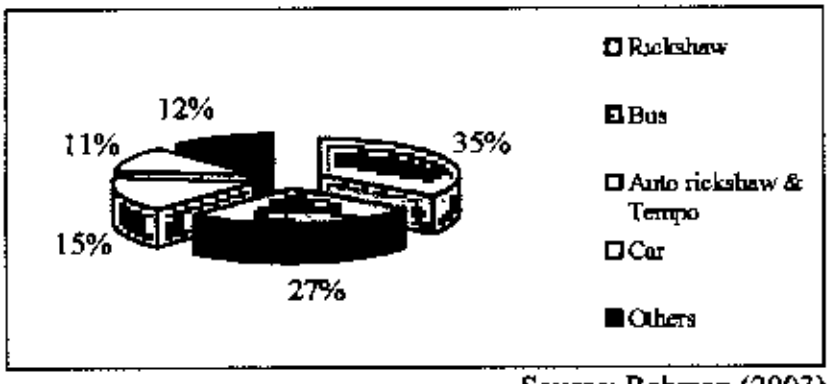
The supply of public transportation is not only insufficient to meet the demand it is also not balanced. Private sector operators are the major parties for providing public transportation with large demand, which makes for competing rather complementing roles for bus and auto rickshaws and even rickshaw.

Table 4.1: Public Transport Modes in Dhaka City

Modes		Seating capacity	Estimated number of Units		Nature of Route	Fare level Tk/km
			BRTC	Private		
Bus	Double decker	78	113	1200	Fixed	0.50 Tk/km (without AC)
	Standard	52	235		Fixed	
	Mini bus	35			Fixed	
Premium Bus (with AC)		45		43	Fixed	1-1.5 Tk/km
Tempo		10		10000	Fixed	1 Tk/km
Human hauler		12		150	Unfixed	1 Tk/km
Auto rickshaw		2		50000	Unfixed	6-7 Tk/Km
Rickshaw		2		500000	Unfixed	5 Tk/km
Taxi		3		200	Unfixed	First 2km 20 Tk add 8Tk/km

Source: Ahsan, 2003

Buses, auto-rickshaws (three-wheeler CNG) and rickshaws are the three major modes of public transport in Dhaka. The following chart illustrates the percentage of person trips in different transport modes (public and private) in the city:



Source: Rahman (2003)

Figure 4.1: Daily Person Trips in Different Modes.

At present there are about 4300 Mini buses, 13500 three-wheeler CNG auto-rickshaws, 3200 mishuks (three wheeler auto rickshaw, normally they have 50 cc motorbike engined), 5500 taxicabs and 590 BRTC operated buses for 10 million people (The Daily Inqilab, 2004). A total of 14800 motor vehicles are plying for 10 million people as public transport, means that the person-to-vehicle ratio is 68:1 in Dhaka City. Whereas the carrying capacity of a double decker bus is 78 and there are only 113 double decker buses are serving the city dwellers and the carrying capacity of other busses are only 30 to 50 people. The carrying capacity other public transport modes like auto-rickshaws and human hauler are 2 and 12 respectively. This wide gap between the demand and availability of public transportation increase the huge number of non-motorized transport in Dhaka City. At present more than 0.5 million rickshaws are plying on the road to meet the huge public transport demand (DCC, 2004). The speed of rickshaws (6km/hour) determines or critically affects the traffic flow in many parts of the urban area. Too many and unregulated rickshaws on the roads is one of the most significant causes of traffic congestion.

For serving the needs of a metropolis with a population of 12 million, the present 2350 city buses are far too less, encouraging the introduction of more and more rickshaws, auto-rickshaws, cars etc on the city roads everyday. Smooth traffic systems demand roads and lanes to be constructed on 25% of the city's surface area, but for Dhaka City the figure is only 8% (Rahan, 2000). A double decker bus occupies $1/7^{th}$ (one seventh) area of the road space in comparison to a rickshaw for carrying an equal number of passengers. Thus the more double-decker and single decker buses are introduced on city roads, the more efficient use of road space can be made.

4.2 PATTERN OF PUBIC TRANSPORT SERVICES IN DHAKA CITY

The present of pattern of public transport services in Dhaka City consists of both fast and slow speed vehicles, viz rickshaws, auto-rickshaws, mishuks, human haules, taxicabs, minibuses, large single-decker CNG operated buses and double-decker buses. Among all those types, the rickshaw, the slowest of all the modes is generally used for door to door service and does not make any long haul trip due to restriction of routes for rickshaw movement. Apart from rickshaws, all other modes are motorized

and they operate at higher speeds than the rickshaws and are also used for longer haul trips. The auto-rickshaws are another mode of public transport used for door-to-door services but are the costliest. The human hauler is a small mode of motorized vehicles has two banks of seats at the back to carry ten persons and one person in the front. They travel from junction to junction. The minibuses are also smaller versions of the buses and operate from junction to junction with seating arrangement for passengers on first come first serve basis along with standing options. The CNG operated single-decker buses were launched recently and they operate without any standing passenger. The buses are the cheapest means of public transport operating in the city routes and they carry a large number of people from one part of the city to another.

4.3 PAST DEVELOPMENT OF PASSENGER BUS SERVICES

Bus services in Dhaka City used to be provided only by the private operators before 1961. Passenger bus services in the city weres first introduced by private bus owners in the early 1950's. Bus services in the public sector were introduced in 1961 by BRTC. Since the beginning of passenger bus services, there were only six routes in Dhaka City. For effective operation of bus services in Dhaka City, the public sector initiated some measures as the private sector could not only meet the growing demand of passenger bus services. After that, the Kalyanpur bus depot was opened in 1964 for city bus services and passenger buses were operated from the year 1965. The Mirpur bus depot was opened for passenger bus services in 1968. From this depot, buses were operated to Gulistan. Two more bus depots were opened for bus services in 1974. These bus depots were established at Joarshahara and Narayanganj. Inter-urban bus services were operated from these above-mentioned five depots. Later another bus depot was opened at Kamlapur to consolidate BRTC's bus operation in Dhaka City.

In response to the popular demand for passenger bus services, a proposal was submitted by the passenger bus owners association to increase the number of routes. Realizing the demand of passenger bus services, DMP (Traffic), the route permit authority at that time in Dhaka City, increased the number of routes from six to thirty nine. Road Transport Committee (RTC) is now responsible and authorized for permitting the new route in Dhaka City.

4.4 GROWTH OF BUS TRANSPORT SERVICE

Passenger transportation services are provided mainly by the private sector and BRTC provides a part. There are about 1700 buses including double-deckers, single deckers, minibuses and premium buses. BRTC is one of the well-organized bus operators with a total of 522 standard buses including 255 double-deckers and single-decker buses. Recently Premium (Metro) Bus Services, Nirapad, Roadster bus services, which are also well organized, have been introduced

Restructuring of bus routes is underway under the DUTP to improve the quality of bus services in the city. According to an estimate of the World Bank, 5000 buses are required for smooth mass transportation in Dhaka City (Source: World bank Report, 2001).

The most appropriate and cost effective means of providing mainly road based public transport in the city is by use of large buses. More investment in mass transport systems can greatly ease traffic congestion in Dhaka city. Realizing the present situation and to encourage environmentally friendly transport services, the government of Bangladesh offered tax exemption on CNG operated single and double-decker buses.

From secondary sources in different relevant departments of BRTA, it is found that the number of passenger buses has been increasing very rapidly. In the last three years, its growth was remarkable. From BRTA and DMP (Traffic) sources, it is seen that in 1995, only 465-passenger buses were plying while in 2003 the number was 1553. The number increased in response to the ever-increasing travel demand. In recent years, its growth is very high and it seems that this trend will continue in the near future.

In the following table, the number of passenger buses in different routes and in different years is given with their respective growth rates.

At present the total number of different types of motorized vehicles in Dhaka city is estimated to be more than 2.0Lac. The increase in non-motorized vehicles is significantly higher. Rickshaws including other NMT are now estimated to be 4 Lac in Dhaka city. Presently of road (MT & NMT) traffic of Dhaka city is 650 thousand and the annual growth is about 8%.

Table 4.2 : Number of Motor Vehicles Registered in Dhaka City

Sl#	Type of Vehicles	1995	1996	1997	1998	1999	2000	2001	2002	2003
1.	Motor car	6923	8386	6528	4984	4330	8386	8969	9875	10120
2.	Jeep/Wagon/Microbus	1556	1387	1492	1438	1371	1387	1492	1438	1371
3.	Taxi	25	35	14	102	215	398	950	1600	2500
4.	Bus	145	73	58	184	224	345	390	580	630
5.	Minibus	324	167	397	300	215	290	357	890	923
6.	Truck	802	615	834	1681	855	823	950	890	965
7.	Auto rickshaw/Auto tempo	7301	4615	1902	1689	682	5400	9800	17650	19980
8	Motor cycle	4427	4027	5346	4992	5330	5800	5675	5700	6435
9.	Others	878	828	310	196	1392	1550	1635	1400	1490
	Total	**22181**	**20133**	**16881**	**15566**	**14614**	**26379**	**32219**	**42025**	**46417**

Source: BRTA, 2005

4.5 BUS TRANSPORT SERVICES IN THE PUBLIC SECTOR

Passenger bus services are operated in the public sector by the Bangladesh Road Transport Corporation (BRTC). BRTC provided approximately 33 percent of its total active fleet for the metropolitan services from the years 1984 to 1988. The growth in number of routes gradually increased from the early stage of bus services in 1965 and its route network doubled in length in 23 years from 1965 to 1988.

In the initial years BRTC operated services with standard single-decker buses. Double-decker buses were introduced first in the year 1968. However most of these buses became inoperative by 1975 and after that only a few were running. In 1988, twenty double-decker buses were purchased for the routes of Dhaka City and operated from Mirpur bus depot. From that time, double-decker buses again became an important travel mode for passenger services in Dhaka city.

Recently, the fleet of BRTC buses and the number of routes have increased simultaneously. The present position of the BRTC fleet size and the number of routes in Dhaka City are stated in the following table.

Table 4.3: Total Fleet in Operation of BRTC Buses in Dhaka City

Sl. No.	Start Point	End Point	No. of Single Decker Buses	No. of Double Decker Buses	Total Number of Buses
01.	Gabtoli	Gulistan	-	35	35
02.	Dainik Bangla	EPZ Savar	-	10	10
03.	Gulistan	Nabi Nagar	-	11	11
04.	Motijheel	Mohammadpur	15	-	15
05.	Motijheel	Narayanganj	-	15	15
06.	Gulistan	Konabari	15	12	27
07.	Motijheel	Tongi Bridge	23	12	35
08.	Gulistan	Balu Ghat	16	-	16
09	Mirpur-10	Gulistan	1	25	26
10.	Mirpur-12	Gulistan	1	30	31
11.	Gulistan	Gulshan-2	-	15	15
12.	Motijheel	Gulshan-1	-	15	15
13.	Dainik Bangla	Tongi Bridge	20	4	24
14	Dainik Bangla	New Airport	-	2	2
15.	Motijheel	Mirpur-10	10	-	10
16.	Narshingdi	Gulistan	8	-	8
17.	Gulistan	Aricha	15	-	15
Total			**124**	**186**	**310**

Source: BRTA, 2005

4.6 BUS TRANSPORT SERVICES IN THE PRIVATE SECTOR

Bus is the cheapest mean of public transportation operating in the city routes and they carry a large number of passengers from one corner of the city to the other corner. In Dhaka, buses are being operated ion both public and private sectors. It has been found from field survey and discussion with the BRTC and selected private bus services that BRTC, the public bus sector operator is operating about 306 buses while the private sector is operating about 1600 buses in the different routes of the city. Within greater Dhaka, 925 (close approximation) private sector owned buses/minibuses are in operation and in 2005, this number increasing abruptly. This figure includes the current total of 85 premium buses, 96 CNG buses. These vehicles work on seventeen urban routes.

Table 4.4: Performance Indicators of Different Passenger Transport Services

Name of Modes	(a) Average Speed km/hr	(b) Average Trip Length (km)	(c) Average Loading (Nos)	(d) Trip/ Vehicle per day	(e) No of Vehicles in Operation	Average Passenger km/ per day/ vehicle (A)	Total Passenger km/ per day/ mode (T)	% of Total Passenger /km/day per Mode
Human Hauler	20	4.3	8 3	29 8	855	1063.5	9 09	3 9
Minibus	30	15	24	20	450	7200	30.96	13.3
Bus	30	15	62	17	200	15810	31 62	13 6
Auto-Rickshaw	20	8 0	2.0	25	2560	400	10 2	64.3
Rickshaw	9	2.5	1.5	40	100	150	150.0	64.6

Source: (a) & (b) Shankland Cox Partnership (1970); Dhaka Metropolitan Area Integrated Development Project – Working Paper – Transport – Dhaka.
(c) & (d) from discussion with the bus, human hauler and auto-rickshaw owner association.
(e) column from BRTC & DTCB

Chapter Five:
Analysis & Findings

5.1 INTRODUCTION

Different researchers have been repeatedly found out that service evaluation as well as passenger bus service standardizations are related with socio-economic characteristics with a view to considering those factors. The respondents have been asked a few personal questions according to the pre-designed questionnaire. The results of which have been discussed in the followings.

5.2 DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

5.2.1 Age

Figure shows that 45.5% respondents were below 30 years and 46.5% were between 30-45 years and rest 8% residents were above 45 years. Most of the trip-makers were middle-age people. Young people make more trips than the older people do. Along with the increase of age, the number of trip decreases

Result shows in the Motijheel-Uttara route that among the different age group, 46.5% daily trips, the highest number were made of which 21.5% trips were made by younger age people (below 30 years). The second highest number and proportion i.e. 21.3% daily trips were also made from middle age people (30 to 45 years of age) and 2.8% daily trips were from older age (above 45 years).

Table: 5.1 Frequency of Travel by Passenger Bus Service according to Different Age-Group (Motijheel-Uttara)

Recorded age in Year		Frequency of Travel					Total
		Daily	4-6 times in a week	1-3 times in a week	Sometimes, not always	Seldom	
Below 30 years	Count	86	22	12	54	8	182
	% of Total	21.5%	5.5%	3.0%	13.5%	2.0%	45.5%
30 to 45 years	Count	85	33	15	41	12	186
	% of Total	21.3%	8.3%	3.8%	10.3%	3.0%	46.5%
Above 45 years	Count	15	4	13	-	-	32
	% of Total	3.8%	1.0%	3.3%	-	-	8.0%
Total	Count	186	59	40	95	20	400
	% of Total	46.5%	14.8%	10%	23.8%	5%	100%

Source: Field Survey 2005

In the Motijheel-Mirpur route, figures shows that most of the trips made by the young age people of below 30 years and double trips were made by the most of the respondents. The older age group (above 45 years) made fewer trips. From the following table in the Motijheel Mirpur route, 8.5% of the respondents were using daily passenger bus services, 19.0% respondents were using four to six times in a week, 33.5% respondents were using one to three times in a day and only 18.5% of the respondents, who never or hardly made bus trip.

Table: 5.2 Frequency of Travel by Passenger Bus Service according to Different Age-Group (Motijheel-Mirpur)

Recorded age in Year		Frequency of Travel					Total
		Daily	4-6 times in a week	1-3 times in a week	Sometimes, not always	Seldom	
Below 30 years	Count	14	54	72	60	52	257
	% of Total	41.8%	71.05%	53.73%	73.0%	70.27%	63.0%
30 to 45 years	Count	16	20	56	18	16	126
	% of Total	47.06%	26.32%	41.79%	21.95%	21.62%	31.5%
Above 45 years	Count	4	2	6	4	6	22
	% of Total	11.76%	2.63%	4.48%	4.88	8.11	5.5%
Total	Count	34	76	134	82	74	400
	% of Total	8.5%	19.0%	33.5%	20.5%	18.5%	100%

Source: Field Survey 2005

The services selection factors for all the services are dependent on age. Double-decker bus services in the Motijheel-Mirpur route and Green Express Bus Services in the Motijheel-Uttara Route was the highest selected passenger bus services for all the trips. Premium bus services in the Motijheel-Uttara Route and Bikolpo CNG City Bus Services in the Motijheel-Mirpur route came in the second position.

Table: 5.3 Traveling by Different Passenger Bus Services according to Different Age-Group (Motijheel-Uttara)

Recorded age in Year		Types of Passenger Bus Services						Total
		Metro Link	Premium A/C	DD Volvo	Green Express	Metrolink CNG	Mega city CNG	
Below 30 years	Count	26	53	1	56	42	4	182
	% of Total	6.5%	13.3%	.3%	14.0%	10.5%	1.0%	45.5%
30 to 45 years	Count	18	38	-	91	31	8	186
	% of Total	4.5%	9.5%	-	22.8%	7.8%	2.0%	46.5%
Above 45 years	Count	12	10	-	10	-	-	32
	% of Total	3.0%	2.5%	-	2.5%	-	-	8.0%
Total	Count	56	101	1	157	73	12	400
	% of Total	14%	25.3%	0.3%	39.3%	18.3%	3%	100%

Source: Field Survey 2005

Table: 5.4 Traveling by Different Passenger Bus Services according to Different Age Group (Motijheel-Mirpur)

Recorded age in Year		Types of Passenger Bus Services					Total
		Bekolpo City Service CNG	Dhaka Poribahan	Karnafully City Service	Single-Decker BRTC	Volvo DD	
Below 30 years	Count	66	38	36	30	76	246
	% of Total	70.21%	63.33%	50.0%	75.0%	56.72%	61.5%
30 to 45 years	Count	24	20	34	20	46	134
	% of Total	25.53%	33.33%	47.22%	25.0%	34.33%	33.5%
Above 45 years	Count	4	2	2	0	12	20
	% of Total	4.25%	3.33%	2.78%	0	8.96%	5.0%
Total	Count	94	60	72	40	134	400
	% of Total	23.5%	15.0%	18.0%	10.0%	33.5%	100%

Source: Field Survey 2005

Middle and older age group of people used Double-decker Volvo in the Motijheel-Mirpur route and in the Motijheel-Uttara route, young age people mainly chooses the Green Express CNG Bus services for the preferable mode of travel. Mostly out of the 186 respondents bus trips, 91 respondents trips were from younger age group of people.

5.2.2 Sex

Table shows that the out of 400 respondents 58.2% respondents were male where 41.8% of the respondents were female. On an average male travel more trips than female. Selection of passenger services also influenced by sex. Females are comparatively chooses the standard and comfortable services. Survey data shows in the Motijheel-Mirpur route that out of total 260 number of trips, male respondents made 98 trips twice in a day i.e. 37.7% and female respondents made 48 single trips out of the total female trips of 140 i.e. 34.3% of the total female trips.

Table: 5.5 Trip Made by Different Age Group according to Sex (Motijheel-Uttara)

Recorded age in Year		Sex of the Respondents		Total
		Male	Female	
Below 30 years	Count	99	83	182
	% within Sex	42.5%	49.7%	45.5%
	% of Total	24.8%	20.8%	45.5%
30 to 45 years	Count	102	84	186
	% within Sex	43.8%	50.3%	46.5%
	% of Total	25.5%	21.0%	46.5%
Above 45 years	Count	32	-	32
	% within Sex	13.7%	-	8.0%
	% of Total	8.0%	-	8.0%
Total	Count	233	167	400
	% of Total	58.2%	41.8%	100%

Source: Field Survey 2005

Table: 5.6 Trip Made according to Sex (Motijheel-Mirpur)

Age Group		No. of Trips						Total Respondent
		0	1	2	3	4	5	
Male	Count	24	54	98	48	20	16	260
	% of Total	33.33%	67.5%	73.13%	64.86%	90.91%	88.89%	65.0%
Female	Count	48	26	36	26	2	2	140
	% of Total	66.67%	32.5%	26.87%	35.14%	9.09%	11.11%	35.0%
Total Respondent	Count	72	80	134	74	22	18	400
	% of Total	18.0%	20.0%	33.5%	18.5%	5.5%	4.5%	100%

Source: Field Survey 2005

Table: 5.7 Distribution of the Number of Trips According to Different Bus Services and Sex (Motijheel-Mirpur)

Sex		Bus Services					Total Respondent
		Bekolpo City Service	Dhaka Poribahan	Karnafully City Service	Single-Decker	Volvo DD	
Male	Count	96	40	40	18	74	268
	% of Total	64.86%	66.67%	58.82%	60.0%	78.72%	67.0%
Female	Count	52	20	28	12	20	132
	% of Total	35.14%	33.33%	41.18%	40.0%	21.28%	83.0%
Total Respondent	Count	148	60	68	30	94	400
	% of Total	37.0%	15.0%	17.0%	7.5%	23.5%	100%

Source: Field Survey 2005

5.3 SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

Table 5.8 shows that most of the respondents in the Motijheel-Uttara route use Green Express CNG Bus Services and premium bus services and they make their trips for work and educational purposes (30.5% and 17%). The next major response was business (14%), home trip (11.3%), social (10%) and shopping (9.3%) respectively. 3.3% respondents mentioned other purposes.

Table: 5.8 Purpose of Frequently Used Bus Trip by Different Age Group (Motijheel-Uttara)

Recorded age in Year		Purpose of travel								Total
		Business/ Commerce	Educational	Home Trip	Others	Recreational	Shopping	Social	Work	
Below 30 years	Count	4	68	21	10	15	10	16	38	182
	% of Total	1.0%	17.0%	5.3%	2.5%	3.8%	2.5%	4.0%	9.5%	45.5%
30 to 45 years	Count	43	-	14	3	4	17	24	81	186
	% of Total	10.8%	-	3.5%	.8%	1.0%	4.3%	6.0%	20.3%	46.5%
Above 45 years	Count	9	-	10	-	-	10	-	3	32
	% of Total	2.3%	-	2.5%	-	-	2.5%	-	.8%	8.0%
Total	Count	56	68	45	13	19	37	40	122	400
	% of Total	14%	17%	11.3%	3.3%	4.8%	9.3%	10%	30.5%	100%

Source: Field Survey 2005

Table 5.9 shows that in the Motijheel-Mirpur route, most of the respondents make their trips for business and home-trip purposes (24.5% and 17.5%). The next major

response was work (15.5%), educational (10.5%), social (5%) and recreational (5%) respectively. 18.5% respondents mentioned other purposes.

Table: 5.9 Purpose of Frequently Used Bus Trip (Motijheel-Mirpur)

Recorded age in Year		Purpose of travel								Total
		Business/ Commerce	Educational	Home Trip	Others	Recreational	Shopping	Social	Work	
Below 30 years	Count	36	36	50	50	12	8	16	34	242
	% of Total	36.73%	85.71%	71.43%	67.57%	60.0%	57.14%	80.0%	54.84%	60.5%
30 to 45 years	Count	54	4	18	18	8	6	4	26	138
	% of Total	55.10%	9.52%	25.71%	24.32%	40.0%	42.86%	20.0%	41.94%	34.5%
Above 45 years	Count	8	2	2	6	-	-	-	2	20
	% of Total	8.16%	4.76%	2.86%	8.11%	-	-	-	3.23%	5.0%
Total	Count	98	42	70	74	20	14	20	62	400
	% of Total	24.5%	10.5%	17.5%	18.5%	5.0	3.5	5.0%	15.5%	100%

Source: Field Survey 2005

Bus services selection factors for the both routes are also influenced by age. Middle age people (30 to 35 years of age) and younger age people (below 30 years of age) was the highest users of Improved CNG bus services (37.8% and 27% respectively). The next choices for the younger age people are the Auto-rickshaw and Double-decker Volvo bus as their preferable mode of transport

Table: 5.10 Preference of Mode Used by Different Age-Group (Motijheel-Uttara)

Recorded age in Year		Mode Used for trip					Total
		Auto Rickshaw	Minibus	Improved bus Service	Premium Bus Service	Double Decker Bus	
Below 30 years	Count	50	5	108	2	17	182
	% within mode	58.8%	100.0%	37.6%	100.0%	81.0%	45.5%
	% of Total	12.5%	1.3%	27.0%	.5%	4.3%	45.5%
30 to 45 years	Count	35	-	151	-	-	186
	% within mode	41.2%	-	52.6%	-	-	46.5%
	% of Total	8.8%	-	37.8%	-	-	46.5%
Above 45 years	Count	-	-	28	-	4	32
	% within mode	-	-	9.8%	-	19.0%	8.0%
	% of Total	-	-	7.0%	-	1.0%	8.0%
Total	Count	85	5	287	2	21	400
	% of Total	21.3%	1.3%	71.8%	0.5%	5.3%	100%

Source: Field Survey 2005

5.4 OPERATING CHARACTERISTICS

5.4.1 Purpose of Trips Made by Passengers

Trip purpose was divided into seven different categories. These are work, business, and educational, shopping, recreational, social and home trip. Another category namely other was made because some responses did not match the above-mentioned categories.

Work trips are as all journeys from home to work places. Business or commercial trips are those from one office or business centre to another for official or business related purposes. Educational trips are defined as trips from home to various educational establishments such as schools, colleges, technical institutes, coaching centres and universities for educational purposes. A shopping is any trip that leads to shops, bazaars, markets etc. Social trips are trips made for socializing (to meet friends and relatives, to visit patients in hospitals etc) or religious purposes. Recreational trips are trips made from home for leisure or recreational purpose

Table 5.6 shows that most of the respondents on the Motijheel-Uttara route use premium bus services and they make their trips for business and commercial purposes (23%). The next major response was educational (16%), home trip (15.5%) and journey to work (15.5%) respectively. 10.5% respondents mentioned other purposes.

Table 5.11: Purpose of Trip by Passengers on Motijheel-Uttara route

Purpose of Travel	Number of Respondent Making the Trip					
	Premium A/C	Double Decker Volvo	Green Express CNG	Metrolink	Mega City CNG	TOTAL
Work	26 (32.5)	16 (20)	8 (10)	10 (12.5)	2 (2.5)	62 (15.5)
Educational	12 (15)	12 (15)	14 (17.5)	14 (17.5)	12 (15)	64 (16)
Business	22 (27.5)	10 (12.5)	24 (30)	10 (12.5)	26 (32.5)	92 (23)
Recreational	0 (0)	0 (0)	4 (5)	6 (7.5)	2 (2.5)	12 (3)
Shopping	4 (5)	4 (5)	12 (15)	0 (0)	2 (2.5)	22 (5.5)
Social	0 (0)	6 (7.5)	10 (12.5)	10 (12.5)	6 (7.5)	32 (8)
Home trip	16 (20)	16 (20)	8 (10)	18 (22.5)	16 (20)	74 (18.5)
Others	0 (0)	16 (200)	0 (0)	12 (15)	14 (17.5)	42 (10.5)
TOTAL	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**400 (100)**

* Figures in parentheses indicate percentage

Source: Field Survey 2005

In the Motijheel-Mirpur route, most of the respondents made their trips for business and commercial purpose (25.5%). The next major response was educational (18.5%), journey to work (17.5%) and social (10.5%) respectively.

Table 5.12: Purpose of Trip by Passengers on Motijheel-Mirpur Route

Purpose of Travel	Number of Respondent Making the Trip					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Work	18 (4.5)	8 (2)	14 (3.5)	18 (4.5)	12 (3)	70 (17.5)
Educational	14 (3.5)	12 (3)	24 (6)	10 (2.5)	14 (3.5)	60 (18.5)
Business/Comm	22 (5.5)	24 (6)	18 (4.5)	20 (5)	18 (4.5)	102 (25.5)
Recreational	2 (0.5)	4 (1)	4 (1)	4 (1)	2 (0.5)	16 (4)
Shopping	2 (0.5)	0 (0)	2 (0.5)	6 (1.5)	0 (0)	10 (2.5)
Social	10 (2.5)	8 (2)	4 (1)	10 (2.5)	10 (2.5)	42 (10.5)
Home trip	4 (1)	12 (3)	4 (1)	4 (1)	14 (3.5)	38 (9.5)
Others	8 (2)	12 (3)	10 (2.5)	8 (2)	10 (2.5)	48 (12)
TOTAL	80 (20)	80 (20)	80 (20)	80 (20)	80 (20)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

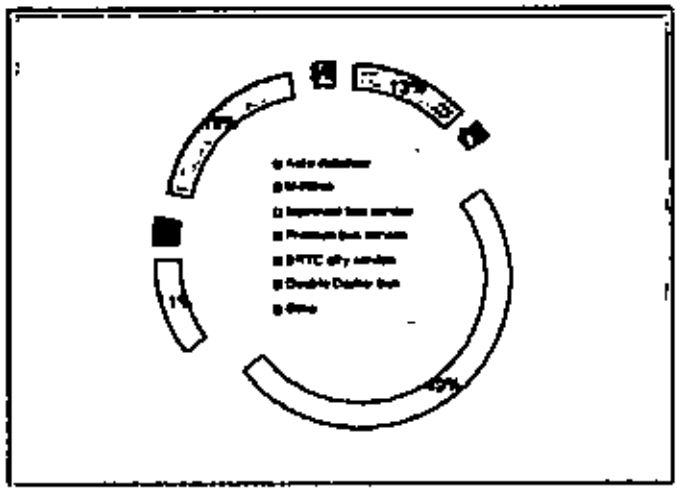
5.4.2 Mode of Traveling by the Passengers

Tables 5.8 and 5.9 show the most preferred modes of the respondents. The figures reveal that 49.5% of the respondents preferred improved passenger bus services for their trip. The next preferred modes of travel are double-decker buses (19.5%), rickshaws (13%) and premium bus service (10.5%) on the Motijheel-Uttara route and on the Motijheel-Mirpur route, the mode of travel preferred are rickshaws (14%), minibuses (12.5%), and double-decker buses (9.5%) following improved passenger bus services

Table 5.13: Mode of Travel Preference by Passengers on Motijheel-Uttara Route

Mode of Travel	Frequency	%
Auto rickshaw	52	13
Minibus	8	2
Improved bus service	198	49.5
Premium bus service	42	10.5
BRTC city service	12	3
Double Decker bus	78	19.5
Other	10	2.5
TOTAL	400	100

Source: Field Survey 2005



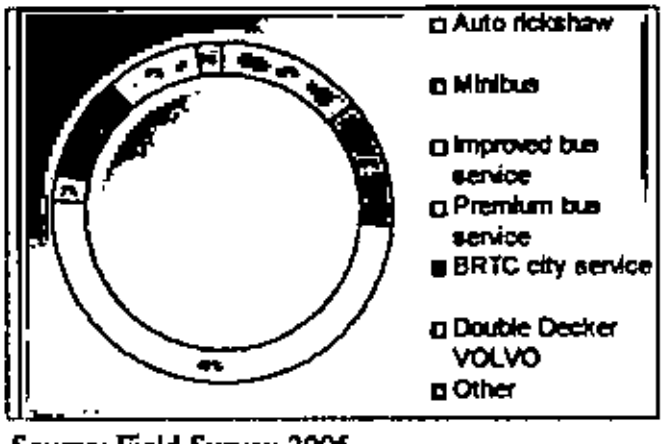
Source: Field Survey 2005

Figure 5.1 : Percentage of the Mode of Travel of Passengers on Motijheel-Uttara route

Table 5.14: Mode of Travel Preference by Passengers on Motijheel-Mirpur Route

Mode of Travel	Frequency	%
Auto rickshaw	56	14
Minibus	50	12.5
Improved bus service	198	49.5
Premium bus service	10	2.5
BRTC city service	40	10
Double Decker bus	36	9
Other	10	2.5
TOTAL	400	100

Source: Field Survey 2005



Source: Field Survey 2005

Figure 5.2 : Percentage of Mode of Travel of Passengers on Motijheel-Mirpur Route

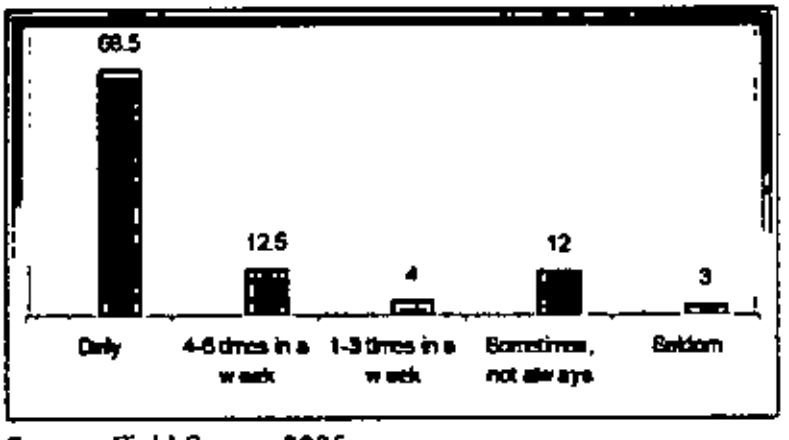
5.4.3 Frequency of Traveling by Passenger Bus Service

It is seen from the table 5.10 and table 5.11 that most of the respondents (68.5% on the Motijheel-Uttara Route and 54.5% on the Motijheel-Mirpur Route) were daily passengers Respondents traveling 4 to 6 times a week constituted the second largest group in the Motijheel-Uttara Route (12.5%) while passengers who traveled sometimes on the Motijheel-Mirpur route constituted the second largest group (18.5%). The third largest group (15.5%) was formed by those passengers, traveling 4 to 6 times on the Motijheel-Mirpur route whereas passenger (12%) traveling sometimes on the Motijheel-Uttara is falling in this group route. Passenger traveling 1 to 3 times in a week (8.0% on the Motijheel-Uttara Route and 4.0% on the Motijheel-Mirpur Route) constituted the fourth and seldom travelers (3.0% on the Motijheel-Uttara Route and 3.5% on the Motijheel-Mirpur Route) constituted the fifth group in respect of size of the passengers.

Table 5.15: Frequency of Travel by Passengers on Motijheel-Uttara Route

Frequency of Travel	No	%
Daily	274	68.5
4-6 times in a week	50	12.5
1-3 times in a week	16	4
Sometimes, not always	48	12
Seldom	12	3
Total	400	100

Source: Field Survey 2005



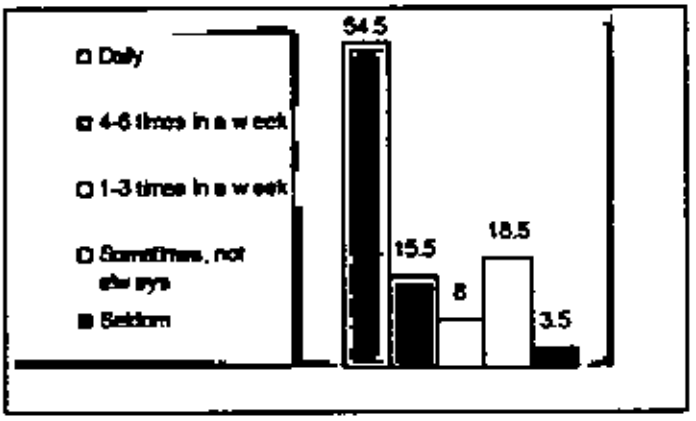
Source: Field Survey 2005

Figure 5.3 : Frequency of Travel by Passengers on Motijheel-Uttara Route

Table 5.16: Frequency of Travel by Passengers on Motijheel-Mirpur Route

Frequency of Travel	No	%
Daily	218	54.5
4-6 times in a week	62	15.5
1-3 times in a week	32	8
Sometimes, not always	74	18.5
Seldom	14	3.5
Total	400	100

Source: Field Survey 2005



Source: Field Survey 2005

Figure 5.4 : Percentage of Travel by Passengers on Motijheel-Mirpur Route

5.4.4 Reasons Behind Traveling by Selected Passenger Bus Service

It is observed from the following table that most of the passengers cite comfort, safety and lower travel time as the reasons behind traveling by the passenger bus service on both routes. The major reason why people use Premium A/C Bus Service is the in-vehicle comfort. The air-conditioned closed environment provides comfort and a feeling of prestige to the passengers. On the Motijheel-Mirpur route, as air-conditioned bus service is not available, double-decker Volvo buses attract passengers for vehicle comfort. On the Motijheel-Uttara route, Mega City CNG Bus Service draws passengers for lower fare and travel time.

Table 5.17: Reasons Behind Traveling By Selected Passenger Bus Service on Motijheel-Uttara Route

Reason of Traveling	Number of Respondent Citing the Reason for Traveling by Bus Services					
	Premium A/C	Double Decker Volvo	Green Express CNG	Metrolink	Mega City CNG	TOTAL
Cost	4 (5)	26 (32.5)	6 (7.5)	28 (35)	30 (37.5)	94 (23.5)
Comfort	42 (52.5)	18 (22.5)	32 (40)	18 (22.5)	4 (5)	114 (28.5)
Less travel time	4 (5)	12 (15)	16 (20)	16 (20)	26 (32.5)	74 (18.5)
Less waiting time	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Safety	12 (15)	14 (17.5)	4 (5)	12 (15)	12 (15)	54 (13.5)
Reliability& regularity	10 (12.5)	6 (7.5)	18 (22.5)	6 (7.5)	6 (7.5)	46 (11.5)
Protection from noise, dust& smoke	4 (5)	2 (2.5)	4 (5)	0 (0)	0 (0)	10 (2.5)
Other	4 (5)	2 (2.5)	0 (0)	0 (0)	2 (2.5)	8 (2)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

Table 5.18: Reasons Behind Traveling By Selected Passenger Bus Service on Motijheel-Mirpur Route

Reason of Traveling	Number of Respondent Citing the Reason for Traveling by Bus Services					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Cost	10 (12.5)	14 (17.5)	16 (20)	10 (12.5)	8 (10)	58 (14.5)
Comfort	22 (27.5)	24 (30)	22 (27.5)	26 (32.5)	38 (47.5)	132 (33)
Less travel time	18 (22.5)	16 (20)	20 (25)	18 (22.5)	16 (20)	88 (22)
Less waiting time	0 (0)	4 (5)	0 (0)	0 (0)	0 (0)	4 (1)
Safety	14 (17.5)	14 (17.5)	16 (20)	20 (25)	14 (17.5)	78 (19.5)
Reliability & regularity	10 (12.5)	4 (5)	2 (2.5)	4 (5)	2 (2.5)	22 (5.5)
Protection from noise, dust& smoke	4 (5)	2 (2.5)	4 (5)	0 (0)	2 (2.5)	12 (3)
Other	2 (2.5)	2 (2.5)	0 (0)	2 (2.5)	0 (0)	6 (1.5)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

5.4.5 Inconvenience Encountered in Using the Different Passenger Bus Services

Respondents' opinion as presented in the following tables 5.14 & 5.15 indicates that the major inconvenience encountered in using the passenger bus service is the low frequency of services provided by the prevailing passenger bus services. This response

frequency of services provided by the prevailing passenger bus services. This response was most frequent for the Green Express CNG and then for the Premier A/C Bus Service. Other difficulties faced by the passengers on the Motijheel-Uttara route are accessibility or load factor (26.5%), limited availability of seat (10%) and high fare (8.5%) and on the Motijheel-Mirpur route, accessibility or load factor (24.5%), limited availability of seats (6.5%) and high fare (5.5%) respectively. For the load factor Metrolink (37.5%) and double-decker Volvo (32.5%) show the highest response on the Motijheel-Uttara route whereas BRTC single-decker (32.5%) and Bikolpo City Super Service (22.5%) show the highest response on the Motijheel-Mirpur route.

Table 5.19: Difficulties Faced by Passengers on Motijheel-Uttara Route

Difficulties Faced by the Passenger	Number of Respondent Mentioning the Inconvenience					
	Premium A/C	Double Decker Volvo	Green Express CNG	Metrolink	Mega City CNG	TOTAL
Limited access or seat	8 (10)	4 (5)	2 (2.5)	2 (2.5)	24 (30)	40 (10)
Problem of fare	16 (20)	8 (10)	4 (5)	4 (5)	2 (2.5)	34 (8.5)
Stoppages too far apart	6 (7.5)	6 (7.5)	2 (2.5)	0 (0)	4 (5)	18 (4.5)
Low speed	8 (10)	6 (7.5)	2 (2.5)	6 (7.5)	0 (0)	22 (5.5)
Low frequency of service	36 (45)	30 (37.5)	58 (72.5)	38 (47.5)	18 (22.5)	180 (45)
Others (Load factor)	6 (7.5)	26 (32.5)	12 (15)	30 (37.5)	32 (40)	106 (26.5)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

Table 5.20: Difficulties Faced by Passengers on Motijheel-Mirpur Route

Difficulties Faced by the Passenger	Number of Respondent Mentioning the Inconvenience											
	Bikolpo City Service		Dhaka Paribahan		Karnaphully City Service		Single Decker BRTC		Double Decker Volvo		TOTAL	
Limited access or seat	6	(7.5	2	(2.5	2	(2.5	10	(12.5	6	(7.5	26	(6.5
Problem of fare	14	(17.5	14	(17.5	6	(7.5	4	(5	10	(12.5	48	(12
Stoppages too far apart	0	(0	6	(7.5	10	(12.5	0	(0	6	(7.5	22	(5.5
Low speed	6	(7.5	2	(2.5	0	(0	0	(0	0	(0	8	(2.
Low frequency of service	36	(45	42	(52.5	38	(47.5	40	(50	42	(52.5	198	(49.5
Others (Load factor)	18	(22.5	14	(17.5	24	(30	26	(32.5	16	(20	98	(24.5
TOTAL	80	(100	80	(100	80	(100	80	(100	80	(100	400	(100

* Figures in parentheses indicate percentage
Source: Field Survey 2005

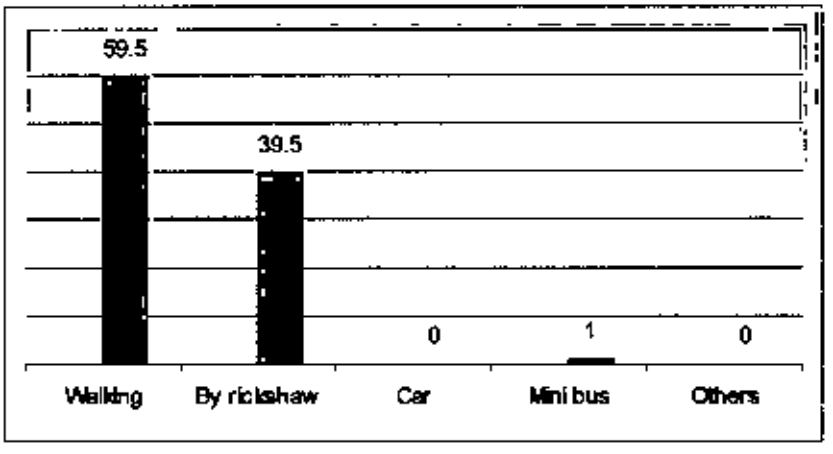
5.4.6 Using of Preferred Modes to Reach Bus Stop

Table 5.16 show that an equal percentage of the passengers used walking for reaching the bus stop for their bus trip to destination in both of the selected routes. The next highest mode used by the passengers is rickshaw (39.5% on the Motijheel-Uttara route and 41% on the Motijheel-Mirpur route respectively)

Table 5.21: Modes Used for Reaching Bus Stop by Passengers on the Motijheel-Uttara Route

Frequency of Travel	No	%
Walking	238	59.5
By rickshaw	158	39.5
Car	0	0
Mini bus	4	1
Others	0	0
Total	400	100

Source: Field Survey 2005



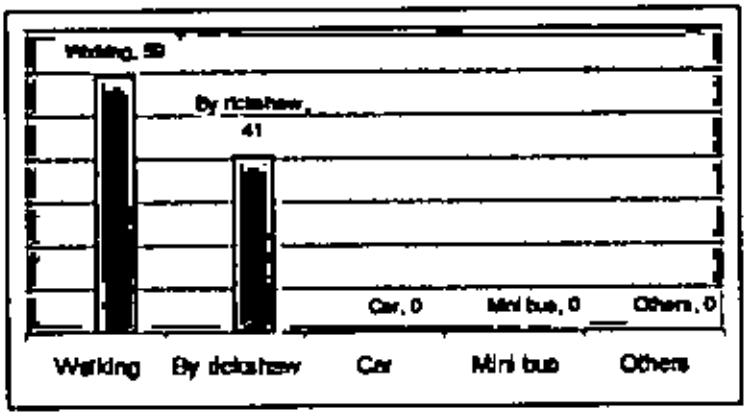
Source: Field Survey 2005

Figure 5.5: Modes Used for Reaching Bus Stop on the Motijheel-Uttara Route

Table 5.22: Modes Used for Reaching Bus Stop by Passengers on the Motijheel-Mirpur Route

Frequency of Travel	No	%
Walking	236	59
By rickshaw	164	41
Car	0	0
Mini bus	0	0
Others	0	0
Total	400	100

Source: Field Survey 2005



Source: Field Survey 2005

Figure 5.6 : Modes Used for Reaching Bus Stop on the Motijheel-Mirpur Route

5.4.7 Time Spent for Reaching Different Bus Service Stops

Table 5.18 and 5.19 show that an equal percentage of respondents (88.5% on the both routes) reached the bus stops within 15 minutes of which the highest proportion (48%) reached the bus stops on the Motijheel-Uttara route within 10 minutes and 53.5% of the passengers reached the bus stops oin the Motijheel-Mirpur route within 15 minutes. The following figure shows that the service area of the Premium bus service is completely within the distance of 20 minutes from the a stop on the route, for the double-decker Volvo, it is completely within the distance of 15 minutes, for the Green Express CNG Bus Service, it is completely within the distance of 15 minutes, for the Metrolink, the entire area is mostly within a distance of 20 minutes and for the Mega City CNG Bus Service is a completely within a distance of 20 minutes from a stop. The service area for Bikolpo City Bus, for the Dhaka Paribahan CNG Bus Services, for the Karnaphuly CNG City Services and BRTC Single-decker Bus Service o the Motijheel-Mirpur route is completely within the distance of 15 minutes respectively and only for the double-decker Volvo, it is mostly within the distance of 20 minutes.

Table 5.23 Time Spent for Reaching the Bus Stop by Passengers on the Motijheel-Uttara Route

Time Spent	Time Spent of the Respondent Using the Selected Bus Service					
	Premium A/C	Double Decker Volvo	Green Express CNG	Metrolink	Mega City CNG	TOTAL
Less then 10 minutes	48 (60)	50 (62.5)	38 (47.5)	24 (30)	32 (40)	192 (48)
10-15 minutes	30 (37.5)	30 (37.5)	42 (52.5)	34 (42.5)	26 (32.5)	162 (40.5)
15-20 minutes	2 (2.5)	0 (0)	0 (0)	18 (22.5)	22 (27.5)	42 (10.5)
More than 20	0 (0)	0 (0)	0 (0)	4 (5)	0 (0)	4 (1)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage

Source: Field Survey 2005

Table 5.24 : Time Spent for Reaching the Bus Stop by Passengers on the Motijheel-Mirpur Route

Time Spent	Time Spent of the Respondent Using the Selected Bus Service					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Less then 10 minutes	18 (22.5)	24 (3)	30 (37.5)	32 (40)	28 (35)	132 (33)
10-15 minutes	56 (70)	46 (57.5)	38 (47.5)	34 (42.5)	40 (50)	214 (53.5)
15-20 minutes	6 (7.5)	10 (12.5)	12 (15)	14 (17.5)	8 (10)	50 (12.5)
More than 20	0 (0)	0 (0)	0 (0)	0 (0)	4 (5)	4 (1)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

5.4.8 Travel Time for Passenger Trip by Different Bus Services

Tables 5.20 and 5.21 demonstrate that a trip time range of 20 to 30 minutes was found for the highest proportion of passengers using the passenger bus service of which BRTC Single Decker Bus Service search out the prior position in the Motijheel-Mirpur route. The next largest proportion (32% in the Motijheel-Uttara and 35.5% in the Motijheel-Mirpur route) of the respondent made a trip of 30-45 minutes duration. Most of the passengers prefer CNG Bus services for this trip duration in the Motijheel-Uttara route and double-decker Volvo in the Motijheel-Mirpur route. Only a few respondents have a travel time less than 15 minutes or more than 45 minutes.

Table 5.25 : Travel Time for Passenger Trip for Different Bus Services on the Motijheel-Uttara Route

Travel Time	Number of Respondent Mentioning the Preferable Travel Time					
	Premium A/C	Double Decker Volvo	Green Express CNG	Metrolink	Mega City CNG	TOTAL
Less than 15 minutes	0 (0)	8 (10)	0 (0)	0 (0)	0 (0)	8 (2)
15-20 minutes	6 (7.5)	10 (12.5)	2 (2.5)	4 (5)	2 (2.5)	24 (6)
20-30 minutes	38 (47.5)	24 (30)	38 (47.5)	38 (47.5)	28 (35)	166 (41.5)
30-45 minutes	12 (15)	28 (35)	36 (45)	16 (20)	36 (45)	128 (32)
More than 45 minutes	24 (30)	10 (12.5)	4 (5)	22 (27.5)	14 (17.5)	74 (18.5)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

Table 5.26 : Travel Time for Passenger Trip for Different Bus Services on the Motijheel-Mirpur Route

Travel Time	Number of Respondent Mentioning the Preferable Travel Time					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Less than 15 minutes	4 (5)	2 (2.5)	4 (5)	0 (0)	0 (0)	10 (2.5)
15-20 minutes	12 (15)	8 (10)	18 (22.5)	8 (10)	6 (7.5)	52 (13)
20-30 minutes	38 (47.5)	22 (27.5)	32 (40)	42 (52.5)	26 (32.5)	160 (40)
30-45 minutes	18 (22.5)	38 (47.5)	18 (22.5)	26 (32.5)	42 (52.5)	142 (35.5)
More than 45 minutes	8 (10)	10 (12.5)	8 (10)	4 (5)	6 (7.5)	36 (9)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

5.4.9 Opinion on Travel Time Regarding Selected Bus Services

Tables 5.22 and 5.23 show the acceptability indices for travel time for selected bus services. These figures reveal that most of the passengers (52.5% on the Motijheel-Uttara route and 56% on the Motijheel-Mirpur route) opined that the travel time on both routes is okay. In the Motijheel-Uttara route the respondent's opinion on acceptable travel time by double–decker Volvo was the highest proportion (52.5%) whereas travel time by Dhaka Paribahan is the highest proportion (47.5%) on the Motijheel-Mirpur route. Only 3% and 7.5% respondent did not make any comment on satisfaction or dissatisfaction with travel time on the Motijheel-Uttara route and Motijheel-Mirpur route respectively.

Table 5.27: Passenger Opinion on Travel Time for Selected Bus Services on the Motijheel-Uttara Route

Travel Time	Respondent Mentioning the Preferable Travel Time					
	Premium A/C	Double Decker Volvo	Green Express	Metrolink	Mega City CNG	TOTAL
Okay	42 (52.5)	36 (45)	34 (42.5)	52 (65)	46 (57.5)	210 (52.5)
Too long	38 (47.5)	42 (52.5)	42 (52.5)	26 (32.5)	30 (37.5)	178 (44.5)
No comments	0 (0)	2 (2.5)	4 (5)	2 (2.5)	4 (5)	12 (3)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

Table 5.28 : Passenger Opinion on Travel Time for Selected Bus Services on the Motijheel-Mirpur Route

Travel Time	Respondent Mentioning the Preferable Travel Time					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Okay	42 (52.5)	40 (50)	54 (67.5)	48 (60)	40 (50)	224 (56)
Too long	24 (30)	38 (47.5)	20 (25)	30 (37 5)	34 (42.5)	146 (36 5)
No comments	14 (17 5)	2 (2.5)	6 (7 5)	2 (2.5)	6 (7 5)	30 (7.5)
TOTAL	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**400 (100)**

* Figures in parentheses indicate percentage
Source: Field Survey 2005

5.4.10 Waiting Time for Different Bus Services

Table 5 24 and Table 5.25 show the waiting time of different bus service on the two selected routes, which were prepared according to respondents' opinion who gave consistent answers in the questionnaire survey. It is observed that waiting time for the majority of bus passengers (81% in the Motijheel-Uttara and 64.5% in the Motijheel-Mirpur route) was within 10 minutes on both routes whereas a waiting time of up to 15 minutes was found in 28.5% cases on the Motijheel-Uttara and 16.5% on the Motijheel-Mirpur route respectively. Lower duration of waiting time was found for larger buses of Premium Bus Service o the Motijheel-Uttara route and double-decker Volvo buses on the Motijheel-Mirpur route.

Table 5.29 : Waiting Time for Passengers for Selected Bus Services on the Motijheel-Uttara Route

Waiting Time	Number of Respondent Mentioning the Waiting Time by the Passengers					
	Premium A/C	Double Decker Volvo	Green Express	Metrolink	Mega City CNG	TOTAL
Less than 5 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5-10 minutes	70 (87.5)	54 (67.5)	66 (82.5)	72 (90)	62 (77.5)	324 (81)
10-15 minutes	10 (12.5)	22 (27.5)	10 (12.5)	8 (10)	16 (20)	66 (16.5)
15-20 minutes	0 (0)	4 (5)	4 (5)	0 (0)	2 (2.5)	10 (2 5)
20-25 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
More than 30 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
TOTAL	***80 (100)***	***80 (100)***	***80 (100)***	***80 (100)***	***80 (100)***	***400 (100)***

* Figures in parentheses indicate percentage
Source: Field Survey 2005

Table 5.30 : Waiting Time for Passengers for Selected Bus Services on the Motijheel-Mirpur Route

Waiting Time	Number of Respondent Mentioning the Waiting Time by the Passengers					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Less than 5 minutes	2 (2.5)	6 (7.5)	0 (0)	8 (10)	4 (5)	0 (5)
5-10 minutes	58 (72.5)	60 (75)	6 (7.5)	64 (80)	70 (87.5)	258 (64.5)
10-15 minutes	14 (17 5)	14 (17.5)	74 (92.5)	8 (10)	4 (5)	114 (28.5)
15-20 minutes	6 (7.5)	0 (0)	0 (0)	0 (0)	2 (2 5)	8 (2)
20-25 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
More than 30 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

5.4.11 Opinion on Waiting Time Regarding Selected Bus Services

Tables 5.26 and 5.27 show the satisfaction index for waiting time for selected bus services on both routes. On the Motijheel-Uttara route 51% passengers expressed their opinion that the waiting time was okay whereas a large proportion of respondent (60 5%) opined that the waiting time for the selected bus services in the Motijheel-Mirpur route was too long. Only 5.5% and 4% respondent did not make any comment on satisfaction and dissatisfaction with waiting time on the Motijheel-Uttara route and Motijheel-Mirpur route respectively.

Table 5.31 : Passenger Opinion on Waiting Time Acceptable for the Selected Bus Services on the Motijheel-Uttara Route

Opinion Regarding Waiting Time	Respondent Mentioning the Acceptability of Waiting Time					
	Premium A/C	Double Decker Volvo	Green Express CNG	Metrolink	Mega City CNG	TOTAL
Okay	28 (35)	42 (52.5)	42 (52.5)	48 (60)	44 (55)	204 (51)
Too long	42 (52.5)	34 (42.5)	38 (47 5)	32 (40)	28 (35)	174 (43.5)
No comments	10 (12.5)	4 (5)	0 (0)	0 (0)	8 (10)	22 (5.5)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

Table 5.32 : Passenger Opinion on Waiting Time Acceptable for the Selected Bus Services on the Motijheel-Mirpur Route

Opinion Regarding Waiting Time	Respondent Mentioning the Acceptability of Waiting Time					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Okay	24 (30)	22 (27.5)	40 (50)	34 (42.5)	22 (27.5)	142 (35 5)
Too long	52 (65)	54 (67.5)	36 (45)	42 (52.5)	58 (72 5)	242 (60.5)
No comments	4 (5)	4 (5)	4 (5)	4 (5)	0 (0)	16 (4)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

5.4.12 Acceptable Maximum Waiting Time for Passenger Bus Service

Acceptable maximum waiting time for the passenger bus services is 10 minutes on the Motijheel-Uttara route passengers. On the contrary, for the Motijheel-Mirpur route passengers opined that their acceptable waiting time was 5 minutes. On both routes, passengers of a double-decker Volvo buses are willing to wait for up to highest duration for their travel trip.

Table 5.33 : Maximum Waiting Time Acceptable to Different Bus Service Passengers on the Motijheel-Uttara Route

Acceptable Waiting Time	Number of Respondent Mentioning the Waiting Time by the Passengers					
	Premium A/C	Double Decker Volvo	Green Express CNG	Metrolink	Mega City CNG	TOTAL
Less than 5 minutes	0 (0)	0 (0)	2 (2.5)	0 (0)	0 (0)	2 (0 5)
10 minutes	76 (95)	78 (97.5)	78 (97 5)	80 (100)	80 (100)	392 (98)
15 minutes	4 (5)	2 (2.5)	0 (0)	0 (0)	0 (0)	6 (1.5)
20 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
More than 20 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

Table 5.34: Maximum Waiting Time Acceptable to Different Bus Service Passengers on the Motijheel-Mirpur Route

Acceptable Waiting Time	Number of Respondent Mentioning the Waiting Time by the Passengers					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Less than 5 minutes	2 (2.5)	8 (10)	0 (0)	10 (12.5)	4 (5)	2 (6)
5 minutes	58 (72.5)	60 (75)	6 (7 5)	62 (77 5)	70 (87.5)	256 (64)
10 minutes	14 (17.5)	12 (15)	74 (92 5)	8 (10)	4 (5)	112 (28)
15 minutes	6 (7 5)	0 (0)	0 (0)	0 (0)	2 (2 5)	8 (2)
20 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
More than 20 minutes	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

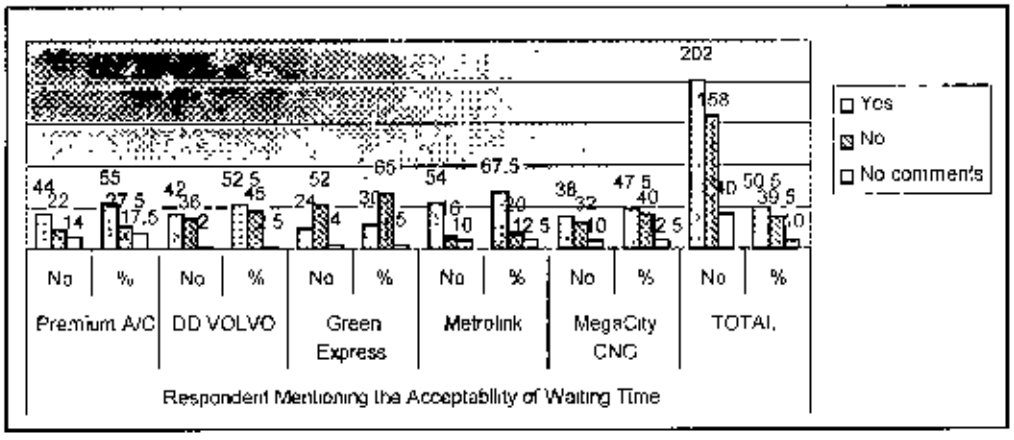
5.4.13 Opinion on Regularity of Selected Bus Services

Bus passengers' opinion on regularity of bus services are presented in the following tables. In the Motijheel-Uttara route, half of the respondents opined favorably regarding the regularity of the services whereas the regularity of the service of selected bus services in the Motijheel-Mirpur route was not satisfactory according to the passengers. About 10% and 4% of the passengers offered no comments on the regularity of services oin the Motijheel-Uttara route and Motijheel-Mirpur route respectively.

Table 5.35 : Passengers Opinion Regarding Regularity of Selected Bus Services on the Motijheel-Uttara Route

Regularity of Service	Number of Respondent Mentioning the Acceptability of Waiting Time					
	Premium A/C	Double Decker Volvo	Green Express	Metrolink	Mega City CNG	TOTAL
Regular	44 (55)	42 (52.5)	24 (30)	54 (67.5)	38 (47.5)	202 (50.5)
Irregular	22 (27 5)	36 (45)	52 (65)	16 (20)	32 (40)	158 (39.5)
No comments	14 (17.5)	2 (2.5)	4 (5)	10 (12.5)	10 (12 5)	40 (10)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005



Source: Field Survey 2005

Figure 5.7: Passengers Opinion Regarding Regularity of Selected Bus Service in the Motijheel-Uttara Route

Table 5.36 : Passengers Opinion Regarding Regularity of Selected Bus Service on the Motijheel-Mirpur Route

Regularity of Service	Number of Respondent Mentioning the Acceptability of Waiting Time					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Regular	14 (17.5)	20 (25)	34 (42.5)	40 (50)	28 (35)	136 (34)
Irregular	58 (72.5)	56 (70)	44 (55)	38 (47.5)	52 (65)	248 (62)
No comments	8 (10)	4 (5)	2 (2.5)	2 (2.5)	0 (0)	16 (4)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005

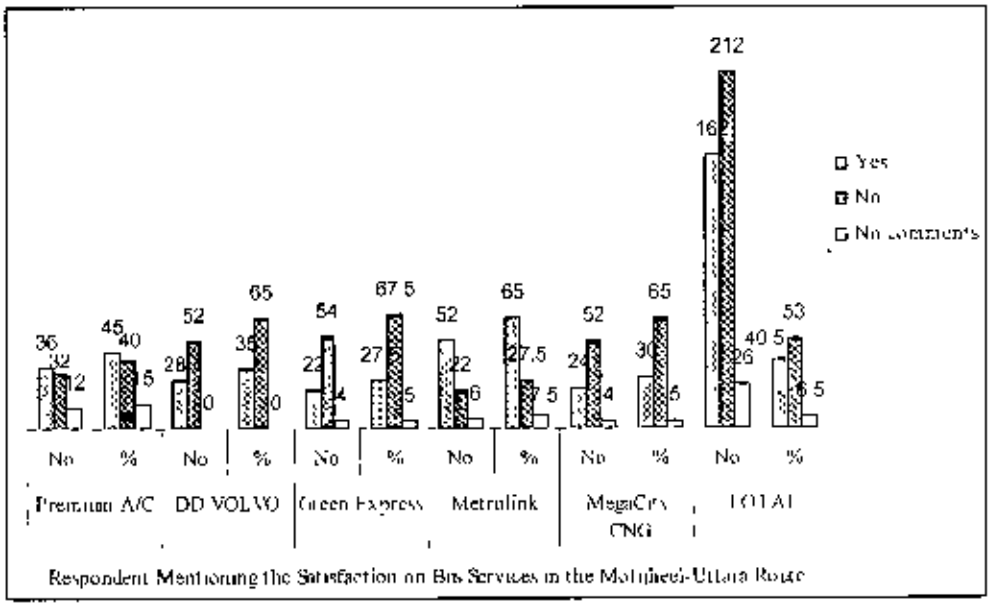
5.4.14 Satisfaction on Selected Bus Services

Tables 5.32 and 5.33 show that the majority of the surveyed passengers were not satisfied regarding the services offered for the passengers so far. Although the highest proportion of double-decker Volvo passenger expressed their satisfaction with the services provided on both routes.

Table 5.37 : Passengers Satisfaction on Selected Bus Services on the Motijheel-Uttara Route

Satisfaction of the Passengers	Respondent Mentioning the Satisfaction on Bus Services on the Motijheel-Uttara Route					
	Premium A/C	Double Decker Volvo	Green Express	Metrolink	Mega City CNG	TOTAL
Satisfied	36 (45)	28 (35)	22 (27.5)	52 (65)	24 (30)	162 (40.5)
Dissatisfied	32 (40)	52 (65)	54 (67.5)	22 (27.5)	52 (65)	212 (53)
No comments	12 (15)	0 (0)	4 (5)	6 (7.5)	4 (5)	26 (6.5)
TOTAL	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**400 (100)**

* Figures in parentheses indicate percentage
Source: Field Survey 2005



Source: Field Survey 2005

Figure 5.8 : Passengers Satisfaction on Selected Bus Services on the Motijheel-Uttara Route

Table 5.38 : Passengers' Satisfaction on Selected Bus Services on the Motijheel-Mirpur Route

Satisfaction of the Passengers	Respondent Mentioning the Satisfaction on Bus Services in the Motijheel-Uttara Route					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Satisfied	20 (25)	18 (22.5)	42 (52.5)	32 (40)	28 (35)	140 (35)
Dissatisfied	58 (72.5)	58 (72.5)	38 (47.5)	48 (60)	52 (65)	254 (63.5)
No comments	2 (2.5)	4 (5)	0 (0)	0 (0)	0 (0)	6 (1.5)
TOTAL	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**400 (100)**

* Figures in parentheses indicate percentage
Source: Field Survey 2005

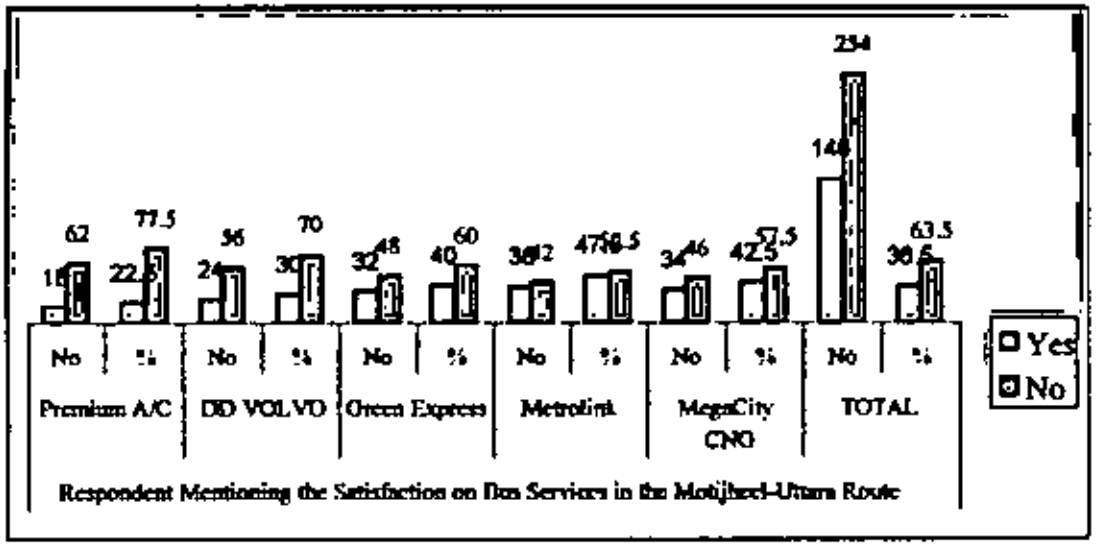
5.4.15 Willingness to Pay Higher Fare for the Improved Bus Services

A total of 800 passengers were interviewed in the passengers' attitude survey of which 400 passengers on the Motijheel-Uttara route and 400 passengers on the Motijheel-Mirpur route. In this survey, each passenger was asked about their actual fare paid and their willingness to pay extra fare for the improved services rather than prevailing passenger bus services systems. Most of the respondents in the both routes opined negative for the paying extra money for the launching of new improved bus services while 36.5% passenger on the Motijheel-Uttara route and 35.5% passenger on the Motijheel-Mirpur route are willing to pay higher fare for the improved passenger bus services if there is any provision.

Table 5.39 : Willingness to Pay Extra Money for the Improved Passenger Bus Services in the Motijheel-Uttara Route

Willingness of the Passengers	Respondents Mentioning the Satisfaction on Bus Services on the Motijheel-Uttara Route					
	Premium A/C	Double Decker Volvo	Green Express	Metrolink	Mega City CNG	TOTAL
Yes	18 (22.5)	24 (30)	32 (40)	38 (47.5)	34 (42.5)	146 (36.5)
No	62 (77.5)	56 (70)	48 (60)	42 (52.5)	46 (57.5)	254 (63.5)
TOTAL	80 (100)	80 (100)	80 (100)	80 (100)	80 (100)	400 (100)

* Figures in parentheses indicate percentage
Source: Field Survey 2005



Source: Field Survey 2005

Figure 5.13 : Willingness to Pay Extra Money for the Improved Passenger Bus Services

Table 5.40 : Willingness to Pay Extra Money for the Improved Passenger Bus Services in the Motijheel-Mirpur Route

Willingness of the Passengers	Respondents Mentioning the Satisfaction on Bus Services on Motijheel-Uttara Route					
	Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	Double Decker Volvo	TOTAL
Yes	26 (32.5)	28 (35)	28 (35)	22 (27 5)	38 (47 5)	142 (35.5)
No	54 (67.5)	52 (65)	52 (65)	58 (72.5)	42 (52 5)	258 (64.5)
TOTAL	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**80 (100)**	**400 (100)**

* Figures in parentheses indicate percentage
Source: Field Survey 2005

Chapter Six:

Application of the AHP & LOS Model

APPLICATION OF AHP IN STANDARD EVALUATION OF PASSENGER BUS SERVICE

6.1 INTRODUCTION

Thomas L. Saaty developed AHP in 1977 for military contingency planning to allocate scare resources, and for political participation in negotiated disarmament agreement. Vargas referred that it is a multiple criterion methodology. In 1990, Saaty explained the AHP as a structured process consisting of a goal, criteria, sub-criteria, and alternative (options) and a set of judgments to establish a relationship amongst them. The ultimate objective is to obtain a scale of relative importance for the alternatives.

6.2. ANALYTICAL HIERARCHY PROCESS (AHP)

The analytical hierarchy process (AHP) is a multi-attribute modeling methodology, which was developed and applied by Saaty. AHP has become a popular tool for problems of multi-attribute decision-making.

The principal idea of AHP is based on pair-wise comparisons at the different hierarchical levels of a problem, which is concerned with evaluating the relative importance of a set of criteria. Pair-wise comparisons of the criteria are represented in a matrix form, from which the relative weights may then be calculated by special procedure. The basic observation is that it is easier to compare the importance of two different criteria than to make an overall comparison in one sweep. For the sake of assessment, a hierarchy of the weightings of the standard evaluation factor is structured. Such a hierarchical structure helps to clarify the relationships among various performance evaluation factors. It, in fact, conforms to the way in which human beings view things.

After defining the problem parameters, the first step in AHP is to decompose the decision-making process into hierarchical criteria levels. For each hierarchy level, the criteria are examined through pair-wise comparison matrix. The weights to be attributed to the different criteria are then calculated as the components of the normalized Eigen vector for the maximum eigen-value of this matrix. This process is

repeated for each hierarchical level of the decision tree. The hierarchy is constructed so that the lower levels of hierarchy are refinements of its upper levels. The decision alternatives are placed on the lowest level of the hierarchy.

Some of the important intangible variables (five performance measures and other criteria namely Travel Time, Waiting Time, Availability of Service i.e. Load Factors, Regularity of Services and Comfort) have been studied to analyze the mode use and selection pattern as well as behavioral pattern of the trip makers and their attitude towards mode choice. The outcome of the model where weightage of different patterns and criteria's those influences the standard evaluation of selected bus services. An endeavor has been made to relate the personal characteristics with the outcome of the AHP model. The main purpose of the AHP model is to investigate the behavioral aspects on preference of the respondents getting the services offered by the contemporary passenger bus services.

6.3. MATHEMATICAL DESCRIPTION OF AHP

The logic of pair-wise comparison of n elements (different criteria) is carried out in a matrix $A = (a_{ij})$.

$$A = \begin{vmatrix} W1/W1 & W1/W2 & W1/W3 & W1/Wn \\ W2/W1 & W2/W2 & W2/W3\ldots & W2/Wn \\ W3/W1 & W3/W2 & W3/W3\ldots & W3/Wn \\ \ldots & & & \\ Wn/W1 & Wn/W2 & Wn/W3\ldots & Wn/Wn \end{vmatrix}$$

Where the elements of the matrix are the pair-wise comparison ratios of the weights W_i.

The pair-wise comparisons are done so that one compares the column unit to the row unit. Thus a matrix ratio is formed with $a_{ij} = w_i / w_j$. The matrix A is reciprocal $a_{ji} = 1/a_{ij}$ and all its diagonal entities are unity ($aii = 1$). For such a study, a total of $n^*(n\text{-}1)/2$ comparative judgments are thus required, where n is the number of criteria used to evaluate the considered hierarchical level.

The matrix rank of A is one and the following equation holds: $A*W = n/W$

Where $W = (w1, w2, \ldots, wn)$

W is the relative weight vector and n is the number of elements.

The problem of finding W has thus been recast in terms of a matrix algebra eigen-value equation with n as the eigen- value and W as right eigen vector of the matrix A.

6.4. STRUCTURE OF AHP MODEL

AHP organizes the various factors of a problem into a hierarchy similar to a tree type structure (Figure-6.1). The top level contains the Goal. Intermediate levels represent the factors and criteria of the problem. At the bottom of the tree are the leaves, which represent the choice or alternatives. A complex model may have additional level to represent further breakdowns of the main criteria into sub-criteria.

Hence Premium Bus Services, Green Express CNG Services, Metrolink, Mega City CNG Services and Double-Decker Volvo on the Motijheel-Uttara route and Bokilpo City Service, BRTC Single Decker, Karnaphully CNG City Service, Dhaka Paribahan and Double-Decker Volvo on the Motijheel-Mirpur route have been selected for the comparison. A higher number of alternatives in this level increase the complicity of the questionnaire. Hence the number has been restricted to only five (figure:6.1).

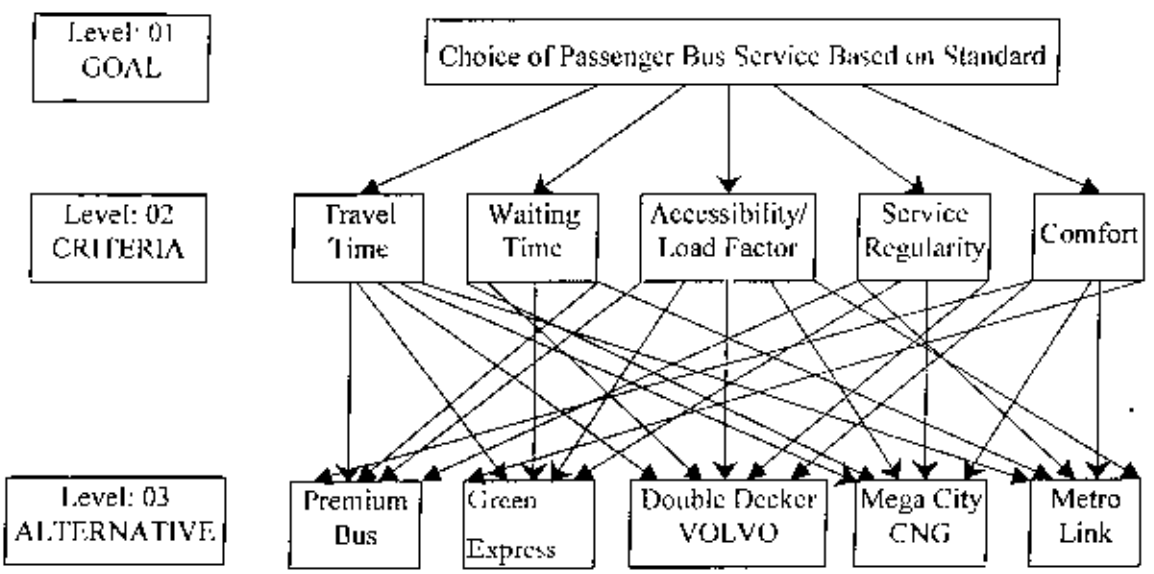


Figure 6.1 Hierarchical Structure of the AHP Model

6.5. AHP MODEL AND AGGREGATION TECHNIQUES IN AHP ANALYSIS

According to AHP model choice process is to be structured in hierarchical order, in different levels such that the factors in each level is related to at least one factor of each preceding and the succeeding levels. Here in the best policy choice method, the selection process has been divided into four levels as follows:

LEVEL 01: GOAL of the structure is to find out the "Determination of the Relative Importance of the Selected PM and selected bus services"

LEVEL 02: CRITERIA, the factors on which standard evaluation depend more. Five most important criteria have been selected for the selecting of service standard. These are time of travel and waiting, regularity of service, accessibility or load factor and comfort.

LEVEL 03: The elements in the third level of the choice hierarchy are the selected services of the passenger bus service domain in the particular route of Dhaka city.

The process begins by preparing the decision factors and constructing a hierarchical structure that will serve as the input data in the AHP module. The AHP involves prioritizing the decision factors based on the hierarchical framework, descending from a goal of the task, to group criteria and finally to the alternatives. The individual respondents' preference weights were considered separately on the objectives and alternatives values. The normalized weights and the corresponding consistency ratios were obtained from each matrix developed on the basis of their filled up questionnaire. Only cases consistency ratio is less than 10 percent have been selected for further analysis.

Figure-6.2 shows an example of how the hierarchical structure of decision factors can be established, in which travel time, waiting time, regularity of service, load factor and comfort are criteria and selected bus services are presented as final alternatives.

In the AHP, it is possible to attach a relative preference measure to each criterion selected in the previous step. The hierarchy of the decision criteria that has been established facilitates this process by permitting the focus to be on comparing a small number of criteria at a time. Setting priorities is aided by the pair-wise comparison aspect of the AHP, which allows a comparison of only two criteria at once, eliminating the potential confusion of having to estimate multiple criteria simultaneously. The acquired relative weights of the criteria in different stages of comparisons are synthesized, yielding the composite priorities of all criteria and eventually the relative weights of the alternative.

6.6 PROCEDURES OF STANDARD EVALUATION TECHNIQUE

The procedure of standard evaluation analysis for selected passenger bus services by two defined routes involved the following steps:

- Identification of selected passenger bus services in the two defined routes.
- Defining performances measures (PM's) and determination of scores.
- Acquisition of preferences through questionnaire
- Determination of weights for each factor in terms of services
- Computation of the sum of weighted factor scores for selected bus services.

6.6.1 Identifying of Passenger Bus Services and its Routes

First the passenger bus services to evaluate the standard in terms of services has been selected. Based upon literature survey and discussion with experts, ten bus services, five of each route namely Premium Bus Services, Green Express CNG Services, Metrolink, Mega City CNG Services and Double-Decker Volvo on the Motijheel-Uttara route and Bokilpo City Service, BRTC Single Decker, Karnaphully CNG City Service, Dhaka Paribahan and Double-Decker Volvo on the Motijheel-Mirpur route have been selected for the comparison and priorities identification in terms of services standard.

6.6.2 Defining Performances Measures (PM's) and Determination of Scores

For each parameter, five performance measures with scores have been defined. A Six-point scale: 5 (extremely important), 4 (much more important), 3 (more important), 2 (moderately important), 1 (slightly important), and 0 (equally important) scale was used to measure degree of standard of surveyed performance measures. The degree of services and corresponding scores are shown in Table-6.1

Table-6.1 Degree of Services of Performance Measures of Selected Passenger Bus Services

Bus Services	Performance Measures	Degree of Services with Score				
		5	4	3	2	
Premium Bus Services	Travel Time	-	B	-	-	-
	Waiting Time	A	-	-	-	-
	Regularity of Services	-	-	B	-	-
	Load Factor	-	B	-	-	-
	Comfort	A	-	-	-	-
Double Decker Volvo	Travel Time	-	B	-	-	-
	Waiting Time	A	-	-	-	-
	Regularity of Services	-	-	C	-	-
	Load Factor	A	-	-	-	-
	Comfort	-	B	-	-	-
Green Express CNG	Travel Time	-	-	-	D	-
	Waiting Time	B	-	-	-	-
	Regularity of Services	-	-	-	D	-
	Load Factor	-	-	C	-	-
	Comfort	-	-	-	D	-
Metrolink	Travel Time	-	-	-	D	-
	Waiting Time	C	-	-	-	-
	Regularity of Services	-	-	-	D	-
	Load Factor	-	-	C	-	-
	Comfort	-	-	C	-	-
Mega City CNG	Travel Time	-	-	-	D	-
	Waiting Time	B	-	-	-	-
	Regularity of Services	-	-	-	-	E
	Load Factor	-	B	-	-	-
	Comfort	-	-	-	D	-

6.6.3 Acquisition of Experts' Preferences

Expert Choice (EC) software is a multi-objective decision support tool based on the Analytic Hierarchy Process (AHP), by which to elicit the value judgments of performance measures on the relative importance of service standard in respect to selected bus services. The experts' preferences or value judgments are 'raw data' for the weighting of performance. There are five steps of acquisition of experts' preference (Figure-7.2).

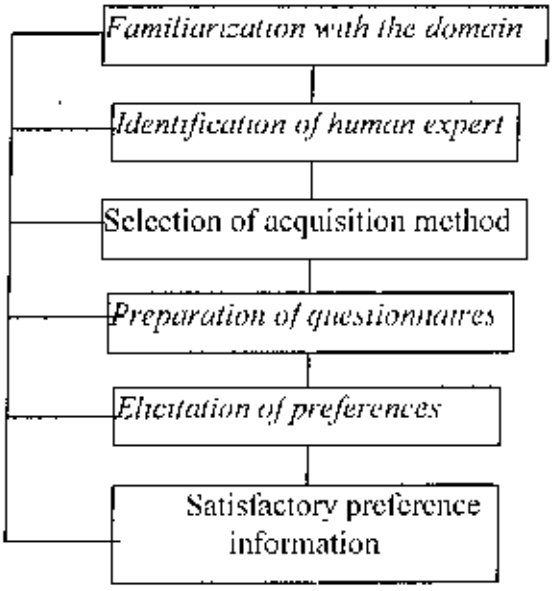


Figure-6.2 Acquisition of Experts' Preferences

a) Familiarization with the domain

The first task in preference acquisition is to determine precisely the goal, objectives or attributes on which preferences were elicited. To this end, a knowledge worker (the software who elicits experts' value judgments) needs to become familiar with the work accomplished in the two previous stages of problem definition and hierarchy construction. The outcomes of these steps include a hierarchy of standardization factor weightings.

b) Identification of Expert

A multi-objective decision support tool "Expert Choice 1.1" based on the Analytic Hierarchy Process (AHP) was identified as an analytical expert of value judgments. The researcher in conjunction with the expert choice accomplished this value judgment process in relation to standard evaluation factors weightings

c) Selection of Acquisition Method

There are various methods to collect data. Among these methods, interviews (either structured or unstructured) are the most commonly used and widely accepted approach to preference acquisition. Pair wise comparisons provide a useful and efficient tool for preference acquisition. This is because it is psychologically easier for most individuals to form pair wise judgments between two particular elements than to compare among the 'n' objects at one time (Saaty, 1992).

d) Preparation of Questionnaires

The questionnaire is prepared for its simplicity and flexibility characterizes a structured interview. The requests for pair-wise comparisons are made through tables rather than questions or matrices. All that an interviewee needs to do is to simply tick to mark with his or her value judgments on which of the two factors is more important and how many times. The interviewee can choose either a numerical or a linguistic scale for pair-wise comparisons. The level/degree of preferences for each pair-wise comparison and the corresponding definitions are contained in Table-6.2. A level of 1 means that both characteristics are equally important. A level of 2 implies that one factor is slightly important than the other is; whereas a level of 5 means that one factor is absolute dominance of one factor over the other.

Table-6.2: AHP Scale for the pair-wise comparisons

Intensity of Importance	Definition and explanation
0	Equal importance (Two factors contribute equally to the objective)
1	Slight importance (Experience and judgment slightly favor one factor over the another)
2	Moderate importance (Experience and judgment moderately favor one factor over the another)
3	More importance (Experience and judgment favors more one factor over the another)
4	Much more importance (Experience and judgment strongly favor one factor over the another)
5	Extreme or Absolute importance (One is of the highest possible order of affirmation as compared to the other)

An excerpt of the questionnaire is given in Appendix-A.

6.6.4 Determining Factor Weights for Each Performance Measure in Terms of Services

Derivation of relative Factor Weights of Performance Measures is completed in this stage. A pair-wise comparison matrix is constructed in analytical tool "Experts Choice 1.1" and then it is applied to these matrices to calculate the weighting scores.

The results of the calculations were then presented to a inventory to the preference information for final evaluation.

6.7 SUMMARY

The detail concept of AHP model, it's calibration procedure and analysis process of experts' choice software by AHP model has been discussed in this chapter. Five performance measures factors, factors rating and factors weight have also been found. From the experts' choice software through AHP technique, these data and factors weight, factors rating have been determined. The result and outcome by the expert choice software was useful to determine composite score of standard evaluation analysis.

Chapter Seven:

Comperative Evaluation of Performance of Passenger bus Services

7.1 RESULTS OF PASSENGER ATTITUDE SURVEY EMPLOYED IN LOS MODELLING

Travel Time

Bus Passengers were asked about opinions on their current level of bus travel time for the selected bus services. About 52.5% passenger in the Motijheel-Uttara route and 56% passengers in the Motijheel-Mirpur route considered their travel time as "okay" and a remarkable figure of passengers considered their travel time as "too long" which are in an amount of 44.5% & 36.5% in the Motijheel-Uttara and Motijheel-Mirpur route respectively. As the notable size of the total respondent were expected to be not satisfied, further inquiries were made about their acceptable levels of travel time compared to an alternative mode.

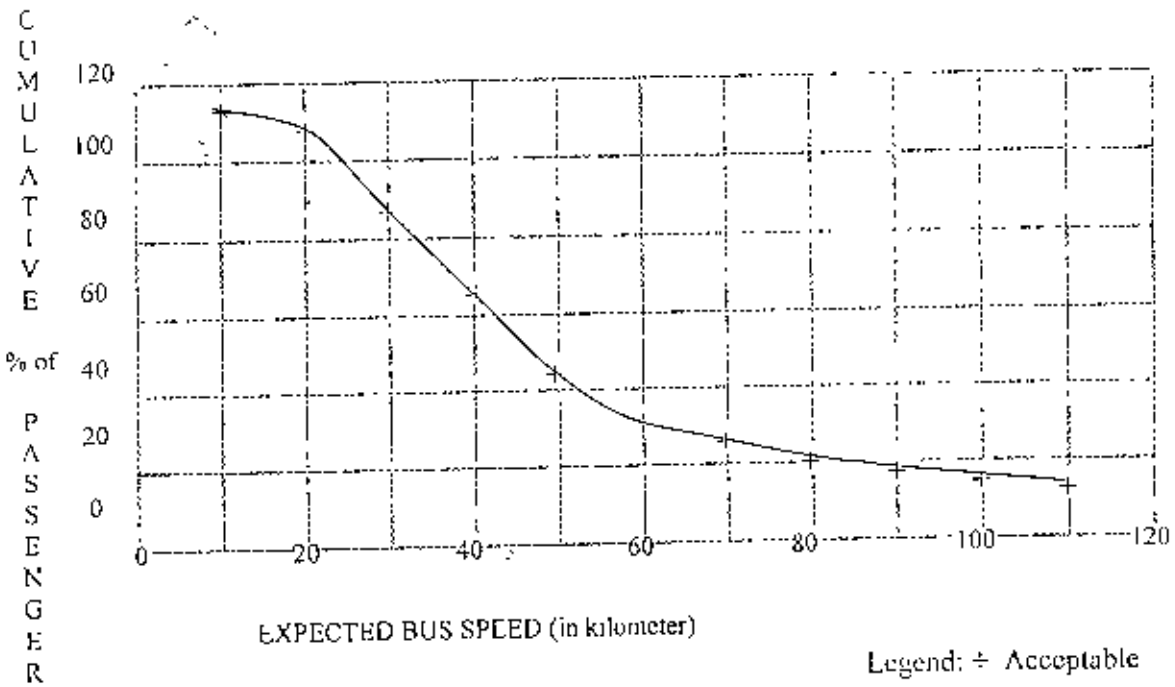
The taxi-cab/car is a viable alternative to bus travel and as such passengers were asked about their expectations of relative travel times by these two modes i e. their opinions regarding how slower bus compared to a taxi-cab/car would be acceptable to them. A wide range of slower bus compared to car in percent form was specified

For convenience of interpolation, the results are presented in figure 7.1, which revealed that a bus slower than car by 35 percent was acceptable to 50 percent of the surveyed bus passengers. On the other hand a fifty percent slower bus (compared to car) was acceptable to only 20 percent of the passengers. The required boundary values for the six service categories of the travel time performance measures were established from these important findings and are presented in a following section.

Waiting Time

Figure 7.2 represents the results of the surveyed passengers' opinion towards their waiting time and duration of waiting time. Passenger waiting times were inquired as suitable or satisfactory and unsuitable or too long together with their existing range of waiting times. Attitude survey results revealed that up to 10 minutes of waiting time was acceptable to more than 50 percent of the bus passengers. Based upon these

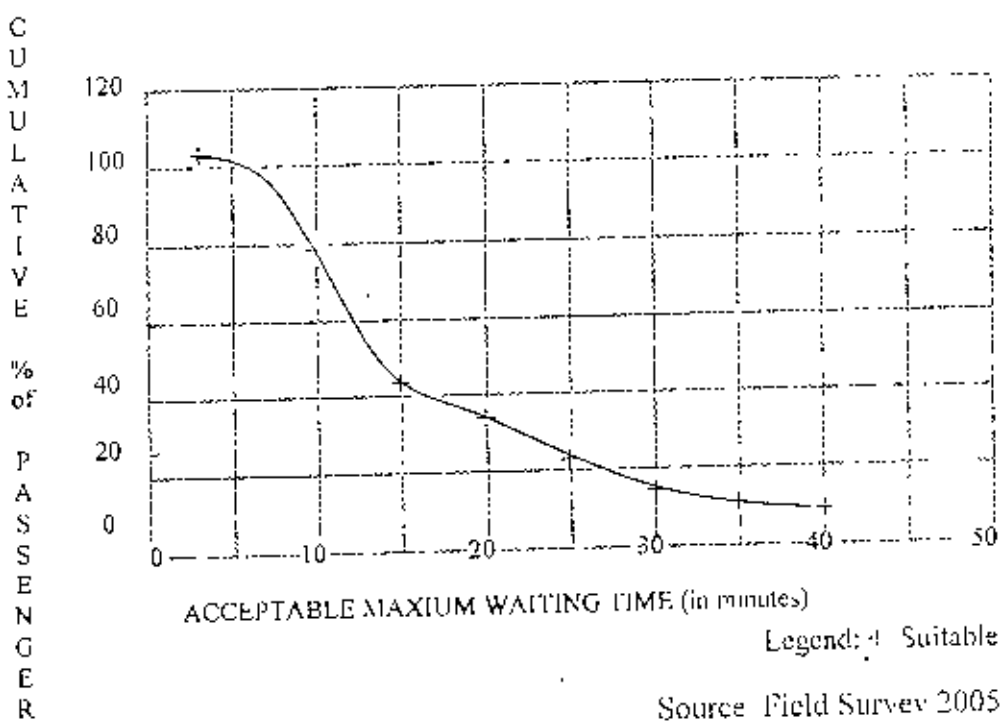
findings about the acceptable levels of waiting time, the required boundary values for the six service categories of the waiting time performance measures were established and are presented as following.



Legend: ÷ Acceptable

Source: Field Survey 2005

Figure 7.1 Acceptable Levels of Bus Speed expected by the Passengers



Legend: ÷ Suitable

Source Field Survey 2005

Figure 7.2 Maximum Waiting Time Suitable to Passengers

7.2 RELATIVE IMPORTANCE OF THE SELECTED PERFORMANCE MEASURES FOR THE PASSENGER BUS SERVICES

Determination of relative importance or weights of the selected PMs are essential for combining the individual LOS categories against the PMs. The technique of Analytic Hierarchy Process (AHP) (Anon., 1992) is employed for this purpose. In order to determine relative importance of the five selected PMs, a simple AHP model will be prepared with five nodes (five PMs) under the goal of "Determination of of relative importance of Passenger Bus Services". Pair-wise relative importance of the passenger bus services against the PM's as obtained from each passengers' response in the attitude survey, will input to the program, and overall relative importance of the PMs assigned by each passenger (respondent) are separately obtained by running the program. However, those judgments of some respondents are discarded which, on being fed into the AHP model, produced an inconsistency ratio beyond a defined limit (3.0). Having thus obtained relative importance of the PMs for individual respondents' responses, average overall weightage for each selected bus services was determined by taking average of all the 'valid' individual respondents' assigned weightages. Application of the AHP methodology provided the relative weights of travel time, waiting time, load factor, service regularity, load factor and comfort as 0.49, 0.29, 0.59, 0.11 and 0.30 respectively. The results revealed that bus passengers considered load factor as the most important attribute followed by travel tie, waiting time, comfort and regularity of services.

7.3 DEFINITION OF STANDARD BUS SERVICE THROUGH THE LOS CATEGORIES

Travel Time

Earlier mentioned that the taxi-cab/car was considered to be a potential competitor of the passenger bus transit and for such reason, bus travel time was compared with taxicab travel time assuming on the same route. Highest or standard condition of bus travel time may be defined as "A" level of services, if bus travel time would closely match car travel time. It wass arbitrarily defined that the MOE value acceptable to at least 50 percent of the passengers was the "C" level of service. Similarly the MOE

values for the other LOS categories "B", "D", "E" and "F" were determined from the defined minimum percentage of passengers as follows: MOE value acceptable to 75 percent passenger as level B; to 35 percent passenger as level D; to 25 percent passenger as level E and to less than 20 percent as level F. After defining these minimum percentages of passengers for wach LOS category, A to F, the corresponding values of the MOE were obtained from figure 7.1. the derived LOS category distribution is presented in table 7.1.

Table: 7.1 LOS Distribution for Travel Time

LOS Category	Defined Percentage of Passenger	Acceptable Levels of a Slower Bus (from figure 7.1)
A	100	0 percent
B	75	23 percent
C	50	35 percent
D	35	42 percent
E	20	50 percent
F	<20	>50 percent

Waiting Time

Waiting time is another important factor that influences the standard and quality of bus services. Collecting data on actual waiting times, however, did not prove to be a feasible proposition for two reasons that a huge number of bus stops might have to be surveyed. Secondly, as several bus routes may use the same stop, it is difficult to conduct such a survey due to passenger identification problems. In the case of randomly arriving passengers it has been shown by Bowman and Turnquist (1981) that the expected passenger waitin time is given by:

$$w = h/2\,(1 + cv^2(h)) \quad \ldots \quad (1)$$

where,

w = mean passenger waiting time,

h = mean headway, and

$cv(h)$ = coefficient of variation of headway.

Boundary values for the six service levels, A through F were established based on the attitude survey results presented in figure 7.2. Similar to travel time, acceptable levels to dfined minimum percentages of passengers were applied as the criteria to establish the boundaries of the six service levels. The resulted distribution is presented in table 7.2.

Table: 7.2 LOS Category Distribution for Waiting Time

LOS Category	Maximum Waiting Time in Minutes
A	5
B	8
C	10
D	15
E	20
F	>20

Load Factor

Passenger comfort is greatly concerned with the load factor, which can be measured directly from the level of loading or actual physical space occupying and was identified by the bus passenger as the most important PM. Considering a greater tolerance limit of the people of the developing countries, it would not be appropriate to compare available space on-board with any western standard. A typical standard followed in the western countries is 0.4 square meters per passenger (CUTA, 1985). Under "crush load" conditions, a standard of 0.2-0.3 square meters per passenger is considered. Moreover, according to survey conducted, the adopted standard to determine legal capacities of buses in Dhaka is even lower than the standards adopted for Bangkok (by Quium and Tanaboriboon, 1994) which is a Third World city. However, load factor compared to legal capacity is taken as the MOE for this PM and legal capacity of buses for Dhaka is estimated according to on-board survey conducted and from the survey findings of previous studies.

The stated legal capacity of buses related to a standard based on number of seats plus 6 passengers per square meter for the standees are arbitrarily defined as the C level.

The lower limit for the E level is defined based on "crush-load" limit of 10 passengers per square meter space for the standees. Other levels are established in relation to these defined levels. Ultimately the LOS categories are determined considering standards and results of bus-occupancy survey actually administered for Dhaka. The distributon of LOS categories for the load factor is presented in the table 7.3.

Table 7.3: LOS Category Distribution for Load Factor

LOS category	Maximum passenger load per capacity
A	0.70
B	0.80
C	1.00
D	1.20
E	1.30
F	> 1.30

Regularity of Service

Regularity of service of a particular transport largely determines its reliability. It affects both passenger waiting time and level of occupancy. Irregularity of service not only decreases rehability but also deteriorates quality of service. Service regularity may be assessed based on the indirect measurement of excess waiting time due to irregular service. Henderson, et al (1991) developed a passenger waiting index based on the original formula put forward by Bowman and Turnquist (1981) as:

$$W = 1/(1 + cv^2(h)) \quad \ldots (2)$$

where,

W = proportion of the average waiting greater than the minimum average waiting

$cv(h)$ = coefficient of variation of headway.

Reciprocal of W indicates how longer is the estimated waiting time than the waiting time when services are perfectly regular. For example, if W is 0.6, it would imply that the estimated waiting time is 1/0.6 or 1.667 times longer than the waiting of a perfectly regular service. W can be expressed in a scale of 0 to 1, where the value "1"

indicates a perfectly regular service. In this research, equation (2) is used to estimate passenger- waiting index as a measure to assess the regularity of the selected ten-bus service in two defined route.

It must be noted here that *cv(h)* was an important parameter in both the equations 1 & 2. As the effect of *cv(h)* was already captured in the waiting time estimation formula, its further inclution may appear to be dubious. However, there are some differences. The waiting time formula estimates the excess waiting time in relative terms. The implications are clear. A service may be regular but still acceptable in terms of waitinf time. On the other hand a regular sercices may not be acceptable considering waitinf time. Therefore, consideration of both the elements is important. Hendersen et al (1991) contended that for psychological reasons regularity of service is important as ach additional minute of waiting increases dissatisfaction disproportionately.

Table 7.4: LOS Category Distribution for Regularity of Service

LOS category	1/W
A	1.10
B	1.30
C	1.50
D	1.75
E	2.00
F	> 2.00

Comfort

In-vehicle comfort or simply comfort is a major factor in attracting travelers to use improved bus services. This PM, comfort is defined to be consisting of five constituent elements, namely cleanliness, crowdedness, temperature, noise and crew behaviour. Each of these elements is placed before the passengers for evaluation on a 6-point scale (0 to 5) where 0 indicated the least acceptance or the worst performance and 5 indicated extreme acceptance or excellent performance. Individual acceptability/ performance index for each element is then calculated for all respondents with help of the following equation.

$$I_a = \sum (s_i f_i) / N \quad \ldots \quad (3)$$

where,

I_a = Index of acceptability for service attribute a,

f_i = frequency of respondents giving rating i to service attribute a.

s_i = scale value of the rating i.

N = Summation of frequencies of respondents giving lowest to highest rating = $\sum f_i$

This PM was defined to be consisting of four constituent elements, namely cleanliness, crowdiness, temperature and crew behaviour. Each of these elements were placed before the passengers for evaluation on a 5-point scale (0 to 5) where 0 indicated the least acceptance or the worst performance and 5 indicated extreme acceptance or excellent performance. Individual acceptability/ performance index for each element was then calculated for all respondents with the help of equation 3.

MOE index for the comfort PM was taken to be the geometric mean of the index values for the four constituent elements of comfort. The value of the MOE index thus obtained must lie between 0 to 1.0; it would give some indication of overall acceptability of the service attribute comfort as a whole, in terms of acceptability of existing performance to that percentage of users (respondents) as given by the MOE index value. A value of at least 0.25 and another value of at least 0.55 were arbitrarily taken to define 'E' level and 'C' level of service, respectively. Other service levels for the comfort PM were arbitrarily defined with respect to these two levels, as given in Table 5, based on rationality.

Table 7.5: LOS Category Distribution for Comfort

LOS category	Minimum value of the MOE index (i.e. geometric mean of the acceptability indices of the 4 elements of comfort)
A	0.85
B	0.70
C	0.55
D	0.40
E	0.25
F	< 0.25

7.4 AGGREGATION OF LOS SCORE AGAINST INDIVIDUAL PM'S

The aggregate overall levels of service standard of the selected bus service on the particular two route was determined from the LOS categories against each of the five PMs by employing the assigned points for each category (0 to 5) and the weighting factors found from the survey results. To calculate the overall LOS, the points for an operating LOS against a PM were multiplied by its weighting factor. Summation of the five weighted points provided the overall LOS score.

7.5 APPLICATION OF THE LOS CONCEPT

The concepts outlines in the previous sections were applied to measure the LOS for the selected ten bus services in the two defined route. The determined LOS categories of the bus routes against the five selected PM's are provided in tables 7.6 through 7.10. Table 7.6 provides the LOS categories against the first PM's of travel time. It was second most important among the five PMs. Results revealed that premium bus services in the Motijheel-Uttara route and Double Decker Volvo and Dhaka Paribahan of Motijheel-Mirpurcould be categorized as level B against this PMS. This was the highest level. Two bus services in Motjheel-Uttara route and one in the Motijheel-Mirpur were operating at level C and the rest at level D.

Load factor was most important among the five PM's, the LOS categories against load factor are presented in table 7.8. Average LOS for all routes was lower than the previously discussed LOS against travel time. Only one bus services were providing services at the level B, two bus services were providing at level C, three bus services at level D and one services at level E and one at level F. the LOS categories indicated widespread overcrowding in the passenger buses during the peak hours. Premium bus services in the Motijheel-Uttara route and Double Decker Volvo buses in the Motijheel-Mirpur route known to be the top operational performer was providing service at level C.

Table 7.6: LOS for Travel Time

Motijheel-Mirpur Route				
Bus Services	Average Bus Speed*	Average Taxicab Speed**	Passenger Bus Service Slower by %	LOS Category
Bikolpo City Service	19.93	31.10	35.92	D
Dhaka Paribahan	22.45	31.10	27.81	C
Karnaphully City Service	21.35	31.10	31.35	C
Single Decker BRTC	19.59	31.10	40.23	D
Double Decker Volvo	25.35	31.10	18.49	B
Motijheel-Uttara Route				
Premium A/C Service	30.85	38.97	20.84	B
Double Decker Volvo	27.53	38.97	29.36	C
Green Express CNG	23.90	38.97	38.67	D
Metrolink CNG	23.50	38.97	39.69	D
Megacity CNG Service	22.88	38.97	41.29	D

* Analyses of Time Keeper Form Data and ** Car Travel Time Survey from Navana

Table 7.7: LOS for Waiting Time

Motijheel-Mirpur Route		
Bus Services	Average Waiting Time in Minutes	LOS Category
Bikolpo City Service	6.56	B
Dhaka Paribahan	5.99	B
Karnaphully City Service	8.12	C
Single Decker BRTC	8.25	C
Double Decker Volvo	3.79	A
Motijheel-Uttara Route		
Premium A/C Service	3.91	A
Double Decker Volvo	4.46	A
Green Express CNG	7.97	B
Metrolink CNG	8.23	C
Megacity CNG Service	6.99	B

Source: Calculated by Applying Equation (1)

Table 7.8: LOS for Load Factor

Motijheel-Mirpur Route		
Bus Services	Peak Hour Load Factor	LOS Category
Bikolpo City Service	1.17	E
Dhaka Paribahan	1.10	D
Karnaphully City Service	1.12	E
Single Decker BRTC	1.21	F
Double Decker Volvo	0.86	C
Motijheel-Uttara Route		
Premium A/C Service	0.69	B
Double Decker Volvo	0.81	C
Green Express CNG	1.03	D
Metrolink CNG	1.10	D
Megacity CNG Service	1.15	E

- Analyses of Time Keeper Form Data

Table 7.9: LOS for Regularity of Service

Motijheel-Mirpur Route			
Bus Services	W*	1/W	LOS Category
Bikolpo City Service	0.77	1.31	C
Dhaka Paribahan	0.68	1.46	C
Karnaphully City Service	0.79	1.27	B
Single Decker BRTC	0.77	1.29	B
Double Decker Volvo	0.92	1.09	A
Motijheel-Uttara Route			
Premium A/C Service	0.88	1.13	B
Double Decker Volvo	0.98	1.02	A
Green Express CNG	0.70	1.42	C
Metrolink CNG	0.69	1.44	C
Megacity CNG Service	0.82	1.21	B

Source: Calculated by Applying Equation (2)

Table 7.10: Overall LOS Category for Ten selected bus Services in Two Route

Bus Services	Performance Measure					LOS Points Average	Weighted Points**	Weighted LOS Category
	Travel Time	Waiting Time	Load Factor	Regularity of Service	Comfort			
Motijheel-Mirpur Route								
Bikolpo City Service	D	B	E	C	D	2.40	2.80	D
Dhaka Paribahan	C	B	D	C	B	3.20	3.85	C
Karnaphully City Service	C	C	E	B	C	2.40	3.08	C
Single Decker BRTC	D	C	F	B	E	2.00	2.13	D
Double Decker Volvo	B	A	C	A	B	4.20	5.01	A
Motijheel-Uttara Route								
Premium A/C Service	B	A	B	B	A	4.40	5.49	A
Double Decker Volvo	C	A	C	A	B	4.00	4.75	B
Green Express CNG	D	B	D	C	D	2.60	3.19	C
Metrolink CNG	D	C	D	C	C	2.60	3.10	C
Megacity CNG Service	D	B	E	B	D	2.60	2.91	D

Notes: * A=5; B=4; C=3: D=2; E=1 and F=0

** Weights were: Travel Time=0.26; Waiting Time=0.29

Load Factor= 0.39; Regularity of Service= 0.11 and Comfort=0.30

7.6 PERFORMANCE EVALUATION THROUGH COMPARISON AGAINST GENERAL STARDARD

Evaluation of service performance of selected five bus services in the two routes of Dhaka city in terms of service efficiency and service effectiveness can be carried our roughly by comparing actual performance levels with available general standards. Following simple technique of evaluating bus and service performance can only depict a general basis of comparison of performance, which gives a first comprehensive idea about the leading or lagging condition of the selected bus services with respect to

defined general standard performance levels. These standard values of the performance indicators were set-forth by Wright and Thiriez (1987) in a World Bank Technical paper and are used in this research for building straight comparison of selected five bus service in two selected routes It will be noted here that the standard values given by Wright and Thiriez for the performance indicators are meant to be attainable by the developing countries and considered to be reasonable but not necessary optimal.

Table: 7.11 Performance Indicators of Passenger Bus Services in the Motijheel-Mirpur Route compared to General Standard.

Performance Indicators	Standard General Values	Actual Values				
		Bikolpo City Service	Dhaka Paribahan	Karnaphully City Service	Single Decker BRTC	DD VOLVO
Employee Per Bus Per Day	3 – 8	6.78	5 26	6.75	7 19	4.79
Vehicle Per Km Per Bus Per Day	210 – 260	187**	193**	185**	181**	215**
Vehicle Per Km Per Litre Per Fuel	2–2.5 (M) 2.5-4 (SD)	3.0	6.0	6 0	3.0	2.5
Vehicle Utilization	80% - 90%	79.5**	86.5**	81.5**	82 4**	91.3**
Vehicle Km Per Accident	100000	N/A	N/A	N/A	N/A	N/A
Revenue Per Operating Expenses	1.05 to 1.08	N/A	1 04	1.03	N/A	1.68

- *Wright and Thiriez

** Estimated Average Value of the whole fleet

Table: 7.12 Performance Indicators of Passenger Bus Services in the Motijheel-Uttara Route compared to General Standard.

Performance Indicators	Standard General Values	Actual Values				
		Premium A/C	DD VOLVO	Green Express CNG	Metrolink CNG	Mega City CNG
Employee Per Bus Per Day	3 – 8	4.68	4.71	6.26	5.75	6.75
Vehicle Per Km Per Bus Per Day	210 – 260	165**	215**	185**	190**	188**
Vehicle Per Km Per Litre Per Fuel	2–2,5 (M) 2.5-4 (SD)	3.0	2.5	6.0	6.0	6.0
Vehicle Utilization	80% - 90%	68.2**	89.3**	81.3**	86.8**	82.5**
Vehicle Km Per Accident	100000	N/A	N/A	N/A	N/A	N/A
Revenue Per Operating Expenses	1.05 to 1.08	1.22-1.30	1.73	1.04	1.03	1.03

- *Wright and Thiriez

** Estimated Average Value of the whole fleet

Table: 7.13 Performance Indicators for Bus Companies in Developing Countries

No	Performance indicator		Range
1	Passenger carried per day	Minibus	600-800
		Single Decker Bus	1000-1200
		Double decker bus	1500-1800
2	Kilometers per bus per day		210-260
3	Kilometers per bus per hour		0.3-0.4
4	Staff employed per bus	Administrative	0.5-1.5
		Maintenance	3-8
		Total	
5	Accidents per 1000000 bus kilometers		1.5-3.0
6	Fleet availability and fleet utilization		80%-90%

7	Fuel consumption: Litres per bus per 100 km	Minibus	20-25
		Single Decker Bus	25-40
		Double decker bus	40-50
8	Operating ratio (revenue divided by total operating cost)		1.05:1 - 1.08:1

Source: Wright and Thiriez (1987)

7.7 SUMMARY

From the above table it is observed that regarding employee per bus, Premium Bus Services operating at better levels in the Motijheel-Uttara route and Double Decker Volvo in Motijheel-Mirpur route compared to general standards Double Decker Volvo in the Motijheel-Uttara route and Dhaka Paribahan in Motijheel-Mirpur route fall in the next group. Whereas out of the selected ten passenger bus services single decker BRTC in the Motijheel-Mirpur route was operating beyond the specified standard.

Double Decker Volvo bus services was using fuel in quantity well within standard but CNG bus services using lower quantity of price on fuel cost compared to standard Whereas Premium bus services using greater quantity of fuel compared to the standard of fuel because of air-conditioned services, which required extra fuel and is not provided in the general standard.

For passenger carrying and with respect to vehicle utilization, double decker Volvo bus services in the both routes operating at the highest levels. Other CNG bus services in the Motijheel-Mirpur route fall in the next group.

Chapter Eight:

Summary of Findings and Conclusion

8.1 SUMMARY OF FINDINGS

From the passengers' attitude surveys, results shows that young people (below 30years) and middle aged people (30-45 years) made highest number of daily trips and young people (below 30years) constituted the largest proportions of Premium Bus Services and Green Exporess CNG bus passengers in the Motijheel Uttara route and Double Decker Volvo and Bikolpo Citye Service bus passengers in the Motijheel-Mirpur route.

On an average male travel more trips than female. Females are comparatively chooses the standard and comfortable services among the selected bus services in the both routes. In the Motijheel-Uttara route women are using the Premium bus services in greater number whereas, in the Motijheel-Mirpur route Bikolpo city service were mostly prefereed by the women respondents.

Most of the passengers in the Motijheel-Uttara route use Premium Bus Services and Green Express CNG services for their work (30.5%) purpose followed by business/commerce (14%), education (17%) and home truip (11.3%). Other were using it for social purpose (10%), shopping purpose (9.3%) and for recreational purpose (4.8%).

The major reason behind using the passenger bus services in the both routes were cost, comfort and safety. Most preferences on Premium bus services and double decker Volvo in the Motijheel-Uttara route indicates comfort (52.5%) and cost (32.5%) respectively. Whereas in the Motijheel-Mirpur route Double Decker Volvo showed the main reason as cohort (47.5%).

Low frequency of services (49.5% in the Motijheel-Mirpur route and 45% in the Motijheel-Mirpur route) indicates the main difficulties faced by the passenger in the both routes. Load factor fall in the next reason, which were 26.5% in the Motijheel-Uttara route and 24.5% in the Motijheel-Mirpur route.

About half of the respondents placed their opinion as okay or satisfied (56.0% in the Motijheel-Mirpur route and 52.5% in the Motijheel-Mirpur route) on travel time in the both route. But for the waiting time they showed their dissatisfaction (60.5%) in the Motijheel-Mirpur route. 51% respondents showed their satisfaction in the Motijheel-Uttara route.

Results revealed that premium bus services in the Motijheel-Uttara route and Double Decker Volvo and Dhaka Paribahan of Motijheel-Mirpur are categorized as level B against the PMS travel time. This was the highest level. Two bus services, Dhaka Paribahan and Karnaphully Paribahan in Motjheel-Uttara route and Double Decker Volvo in the Motijheel-Mirpur were operating at level C and the rest at level D.

Load factor was most important among the five PM's. Out of the selected ten bus services in the two defined routes, only Premium Bus Services providing services at the level B. Double Decker Volvo in the both route providing at level C; Dhaka Paribahan, Green Express CNG and Metrolink CNG bus services at level D; Karnaphully and Megacity CNG services at level E and only Single Decker BRTC in the Motijheel-Mirpur route providing services at level F. the LOS categories indicated widespread overcrowding in the passenger buses during the peak hours.

it is observed that regarding employee per bus, Premium Bus Services operating at better levels in the Motijheel-Uttara route and Double Decker Volvo in Motijheel-Mirpur route compared to general standards Double Decker Volvo in the Motijheel-Uttara route and Dhaka Paribahan in Motijheel-Mirpur route fall in the next group. Whereas out of the selected ten passenger bus services Single Decker BRTC in the Motijheel-Mirpur route was operating beyond the specified standard.

Double Decker Volvo bus services were using fuel in quantity well within standard but CNG bus services using lower quantity of price on fuel cost compared to standard. Whereas Premium bus services using greater quantity of fuel compared to the standard of fuel because of air-conditioned services, which required extra fuel and is not provided in the general standard.

For passenger carrying and with respect to vehicle utilization, Double Decker Volvo bus services in the both routes operating at the highest levels. Other CNG bus services in the Motijheel-Mirpur route fall in the next group.

The overall level of service categories for the selected ten bus services in two routes were finally derived through multiplied by their respective weights obtained from AHP to determine the weighted points. Only one bus services from each route, Double decker Volvo in the Motijheel-Mirpur route and Premium Bus Services in the Motijheel-Uttara route providing the standard and highest level of services at A. Double decker Volvo in the Motijheel0-Uttara route proving the services at level B, which indicated the next level of standard among the ten bus services. Overall standard and service level of Dhaka Paribahan, Karnaphully city service in the Motijheel-Mirpur route and Green express CNG and Metrolink services were at level C. and the rest Bikolpo City Service, Single decker BRTC and Megacity CNG services at level D. Premium bus services in the Motijheel-Uttara route and Double decker Volvo in the Motijheel-irpur route were identified as top performer from operational point of view and the overall standard and service level.

8.2 CONCLUSION

Passenger bus service evaluation standard are evolutionary. Bus services standards evaluations are often used for those routes that operate a number of bus services in a common corridor. A methodology has been presented in this research to evaluate the quality as well as standard of prevailing bus services in the selected route of Dhaka city. Five performance measures related to service operations were selected to measure the levels of services offered and provided by the ten selected bus services in two defined route of Dhaka city. These measures were selected primarily due to their policy sensitivity and operator controllability. A dynamic approach was followed to measure the relative importance of the PM's through an analytical tool Expert Choice in order to establish boundary values for the defined six levels of service A through F *An aggregation methodology of AHP was employed and the derived LOS model may* have the implication for many prospective purposes. Is can help the decision makers

to establish certain benchmark to monitor route performance including providing justification for service changes.

8.3 RECOMMENDATION FOR THE FURTHER RESEARCH WORK

The evaluation outcomes clearly indicated the salient features for which the selected bus services were deficient and the levels of such deficiency. Operators could take appropriate measures to adjust the level of service to some standard through operational changes.

References

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REFERENCES

Ahsan, R. (2003). Sustainable Transportation policy for Dhaka City, Bangladesh, Master of Urban Planning Thesis, Dept. of Planning, HongKong University, HongKong.

Das, S. K. (1998). An Evaluation of Premium Bus Service in Dhaka city, Master of Urban and Regional Planning (MURP) Thesis, Dept. of URP, Bangladesh University of Engineering and Technology (BUET), Dhaka.

Development Design Consultant Ltd. and Mott Macdonald Ltd. (1996b). Premium Bus Service 1 and 2 (PBS-1 and PBS-2), Mini Buses for Old Dhaka Scheme (MODS-1), Working Paper No.2, Phase 1, Study of Dhaka Transport Project, Published by BRTA, Government of the People's Republic of Bangladesh.

DITS (Dhaka Integrated Transportation Study), (1994). Final Report, submitted for the GRATER DHAKA METROPOLITON AREA INTGRATED TRANSPORT STUDY, Vol. 1, November 1994.

DUTP (Dhaka Urban Transport Project) Phase II (1998). Draft Final Report, Prepared by PPK, Mac Donald and Development Design Consultant (DDC), Dhaka, Bangladesh.

DUTP (Dhaka Urban Transport Project) Phase I (1996). Public transportation Survey in Dhaka City, Dhaka, Bangladesh.

Esrar, M. Ismat (1992). "Home Based Trip Generation Modeling for Dhaka City" Master of Urban and Regional Planning Thesis, Department of Urban and Regional Planning, BUET, Dhaka, Bangladesh.

Fielding, G. J. and Anderson, S. C. (1984). "Public Transit Performance Evaluation: Appplication to Section 145 Data", Transportation Research Record 947, pp. 1-7.

Fjellstrom, K. (2001). Transport demand Management and Bus Priority, GTZ Sustainable Urban Transport Project, Surabaya 60772, Indonesia

GDMITS (Greater Dhaka Metropolitan Area Integrated Transport Study). 1994. Working Paper No.8, Environment, Planning Commission, Government of Peoples Republic of Bangladesh.

GDMITS (Greater Dhaka Metropolitan Area Integrated Transport Study). Final Report, Vol. 1, Database and Immediate Actions, PPK consultants Pty Ltd, Australia, Delcan International Corporation, Canada and Development Design Consultants, Bangladesh, November 1994.