Comparing Comfort in Various Public Transportation Modes in Dhaka City

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APPROVAL

The thesis titled “Comparing Comfort in various Public Transportation Modes in Dhaka City” submitted by Mahfuzur Rahman, Kazi Azizul Haque, Sunny Rahman and Shahriar Iqbal Zame, Student ID: 135441, 135446, 135439, 135434 respectively, have been found as satisfactory and accepted as partial fulfillment of the requirement for the Degree Bachelor of Science in Civil Engineering.

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DECLARATION

We hereby declare that the undergraduate research work reported in this thesis has been performed by us under the supervision of Assistant Professor Dr.Moinul Hoissain and this work has not been submitted elsewhere for any purpose (except for publication).

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DEDICATION

We dedicate our thesis work to our family. A special feeling of gratitude to our loving parents.

We also dedicate this thesis to our many friends who have supported us throughout the process. We will always appreciate all they have done.

ACKNOWLEDGEMENTS

All the praises to Almighty Allah for giving us the opportunity to complete this book. We wish to express our sincere gratitude to Assistant Professor Dr. Moinul Hossain for providing us with all the necessary facilities, giving undivided attention and fostering us all the way through the research. His useful comments, remarks and engagement helped us with the learning process throughout the thesis. We would like to express gratitude to all of the departmental faculty members for their help and support. We are also grateful to our parents for their encouragement, support and attention and for being ravished patrons. We also place on record, our sense of gratitude to one and all, who directly or indirectly, have contributed to this venture.

ABSTRACT

The comfort of a transportation trip was measured and correlated with data from two different sources i.e. subjective (Questionnaire survey) approach and mechanical (Arduino) approach for the first time in context to a fast-developing city like Dhaka. Comfort values for two different routes with five different modes were analyzed on the basis of four identified variables (Speed, Vibration, Sound, Temperature) with the help of Anova Test. The f critical values of all the variables are found to be smaller than the f values. We thus can say that the null hypothesis is rejected, implying that with the change of mode, change of identified variables and all over comfort value is directly connected. We also prepared comfort ranges on the identified variables for general passengers. This thesis is a basic survey, which pioneers the way to correlated data analyzing but would require a full-scale survey of all major possible highways in Dhaka city to actually enhance the comfort model. The study requires inclusion of a few more identified variables and a weight study to develop the model in a further level. A whole scale comfort model of the Dhaka city would be a big step forward in correlated data analysis for any developing country. This would help us to design transports and develop policies and strategies towards a more comfortable transport system of Dhaka.

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INTRODUCTION

1.1 Introduction

Travelers' comfort in a mode relies upon a different variable other than travel time. With a specific end goal to build sustainable transport system, transport administration ought to be planned in a way that it suits the administration levels required by clients. This study is an attempt to provide a better definition of comfort in public transport of the Dhaka city, using one of the two most important routes and taking 5 kinds of popular modes to get our data.

Our analysis would result in a comfort range for all the modes. Google defines comfort in the following way – "Improve the mood of or restore a sense of physical well-being to."

1.2 Background

Bangladesh is a moderately developing country, with a hugely growing population of 163 million back in 2016 and a growth rate of 1.1 annually. This estimates a projected population of 200 million in 2050 (source:https://www.populationpyramid.net/bangladesh/2050). A huge population means a massive number of transports. This transport system has to meet the substantial human load to ensure sustainable development, meet necessary daily demands, meet economic needs of the country to act as a determining factor of this country's growth. With the increase of population, road infrastructures are not expanding in the same rate. This would lead to definite congestion. Congestion is a direct component of comfort for any place or time.

Our thesis thus also refers to public suffering in various modes of transport in the major Dhaka city, comparing each of them at a quantifiable level through a pioneering approach. With the gradually increasing load of transport, congestion is thus a major problem at hand in the present Dhaka city. And comfort has always been a top criterion for public satisfaction (Lin et al., 2011). Comfort of a transportation trip typically depends on timeliness, cost, speed, safety, security, comfort, availability, vehicle access, service, responsiveness (HCM, 2010).

Some of the major studies in this aspect:

Table 1.1 -Major studies regarding comfort

Measuring Component	Measures	Reference
Cost	Ticket price, Fuel cost	Chou, 2008
Safety	Median, intersection design, number of crashes	Guo et al., 2009
Speed	Fluctuation of speed, acceleration, deceleration	Hoberrock, 2008
Passenger Load Factor	Congestion	Shen et al., 2016
Noise & Vibration	Noise intensity, passengers' perception on bus vibration and braking system	Prashanth et al., 2013

Comfort can be measured in both subjective and mechanical approach. This kind of study has already been done in various developed countries and many of the developing countries. The subjective kind of survey is more like questionnaire surveys, these may also be done using key informant interviews or discussion groups. And for the mechanical survey a mechanical device is used, in our case it's an Arduino with various attachments to measure the key variables for comfort. Comfort Studies in Developing Cities –

Table 1.2 - Comfort Studies in Developing Cities

Name of City	Method	Modes	Reference
Taipei	Subjective (Questionnaire)	Single Bus	Lin et al., 2011
Uttarakhan, India	Mechanical Approach	Single Bus	Prasant et al., 2013

Comfort Studies in Developed Cities –

Table 1.3 - Comfort Studies in Developed Cities

Name of City	Method	Modes	Reference
Taipei	Subjective (Questionnaire)	Single Bus	Lin et al., 2011
Uttarakhan, India	Mechanical Approach	Single Bus	Prasant et al., 2013

1.3 Problem Statement

The key problem we are trying to solve through our research is that all of those surveys were done using either mechanical or subjective approach. And in the context of our country, this thought is really new and pioneering. Apart from this, very little study has been done using Arduino. Various major studies in this field of analyzing the comfort of transportations:

Table 1.4: Major Studies related measuring component & procedures

Measuring Components	Measuring Procedures	Reference
Travel Time	Microphone and Accelerometer	(Miluzzo et al., 2008)
Noise & Vibration	Smartphone's GPS, accelerometer, microphone and communication radios.	(Mohan et al., 2008)
Comfort	GPS of smart phone	(Lin et al., 2011)
Passenger Load Factor	On site survey	(Shen et al., 2016)

Our research thus becomes unique in a strong way by correlating data from two kinds of sources. Thus, we can quantify the human abstract feelings of comfort to comfort ranges with definite values. Our research deals with 5 modes of transport, and 4 identified variables in 2 bus routes in

Dhaka city. We used both ways of data collection in any given trip and recorded required aspects of it.

1.4 Purpose and Objectives

Our thesis heavily relies on focused variables, and thus our purpose in this study is clear. Our analysis will consist of a comfort theme of various modes. Our output would create a quantifiable structure to assign human comfort feelings a numerical value.

Our primary objectives are –

- To measure comfort level for various modes of transports in Dhaka city.
- Using questionnaire approach & mechanical approach for comfort measurement.
- Correlating with Subjective (Questionnaire based) & Mechanical (Arduino Based) results.
- Comparing relative comfort level for 5 types of public transports including Public AC & Non-AC Bus, Rickshaw, Auto, Passenger Car.
- Preparing comfort ranges on 4 factors for general passengers.

1.5 Future Scope:

- In future we can increase more types of transports for comfort analysis.
- In future we can analyze comfort considering more variables such as cleanliness, air quality, seat quality, spacing for legs, behavior of helper, driving skill of driver, security and many more.
- In implementation of new road design in Dhaka City, using our comfort values, suitable modes of transports can be introduced.
- While making a new design of any transport, it's acceleration, speed, temperature, interior sound can be estimated from our comfort ranges for such variables.
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Chapter 2
LITERATURE REVIEW

2.1 Introduction

Transportation system is one of the most important parameter of a country's development cause without it a country can face many problems in every aspect of development. For the development of a country the transportation system should be in good physical condition as well as with comfort and safety. The economic condition of a country is also an important parameter regarding with the transportation system. If the economic condition is not so well then, the road condition, comfort, safety and security all inter related issues declines. The transportation system is upgrading with the advancement of time all over the world and people are now very much concern about the comfort of using the modes of transport. Nowadays it has been found that people are choosing the modes which are fast as well as comfortable. There are different modes of transport and not each of them are capable of providing same comfort and security, some of the modes are more comfortable than the other modes. People are now very much aware about the comfort of transportation modes. In order to measure and compare the people's choice about the comfort of public transport we need some data as well as some survey data of various factors to link with the comfort of transportation.

The main purpose of our research is to compare the comfort level in public transports, means the relation among the public transports with some of the variables which are directly affect the comfort level of any transport. We have gone through some literatures regarding our research and found several important things so that we can use those findings in our research. And in this chapter, we will discuss all of our studies and make an approach to relate them with our own research.

2.2 Transportation System in Dhaka

Being a capital city, it is always very busy with all kinds of transports and this is one of the main reason of being called mega city. The city supposed to have a good transportation system with a high rate of public transport usages. But some problems come to light due to some lacking in the transportation infrastructure. To control a very high-volume transit is necessary which is not preset

here in this city. Ideally in a city with a well-functioning transportation system, about 25% of the land usage should be for road transport. However, in Dhaka the percentage is very poor and its only 8% and two third of this percentage is covered by non-engineered surfaces (Andaleeb et al., 2007). If there are any other options then it would be lot easier of the city to handle such kind of problems for the travelers. In Dhaka there is lack of transit system as well as an organized bus system. The total number of busses available in Dhaka in not adequate to comfortably handle the number of the passengers who are willing to take the service. In a recent report it has been found that Colombo in Sri Lanka has 7600 buses for 4.6 million people, on the other hand Dhaka has only 2000 for ten million (Haque and Hossain, 2004). There are a few people having their own transport to meet their daily necessity of travelling and the percentage is very low. The percentage comprise only at a rate of 33 per 1000 person which is noticeably shorter than any other Asian cities (Barter &Paul, 2000). Normally non-motorized transports cover 80% of the total vehicle movement, over 400000 rickshaw moves all over the Dhaka city and clogs on different streets (Hossain et al., 1999). Normally the pedestrian is higher in Dhaka city comparing any other city in the world like its size. Near about 60% of the people are considered as pedestrian because of economic reason and rickshaw covers 50% of the total traffic flow which is most popular choice of mode for short distance (Andaleeb et al., 2007). Though there is a large amount of non-motorized vehicle, buses are carrying over half of the Dhaka's travelers (Strategic Transport Plan, 2004). There are many travelers who uses train as a mode of their transport and a large number of people of Dhaka city use this mode.

For increasing number of the users more roads, elevated expressway, high-rise parking lot are being made and more space for parking are provided but the citizens are bound to buy car due to lack of adequate facility for public transport, NMT and walking Only 1% citizens own car and 5% trip are made by car loans, ads Parking facility with low cost or without charge Car owners take advantage on all road.

2.3 Public Transportation in Dhaka

Population of Dhaka is increasing on a greater rate as well as the transports to cope with the increasing number of the people. For the increasing number of the vehicles the infrastructure and the transportation system is improving so that it can be meet the demand of the population. Among

the various mode of transport rickshaw, bus, CNG driven auto rickshaw, recently added battery powered auto rickshaw these are commonly known and used as the public transport in Dhaka city.

Normally rickshaw is the most available mode of transport in Dhaka city for roaming around the city and many narrow alleys. The availability of rickshaw and the cheap rate have appealed the city dwellers. There is some variation in rickshaws nowadays because of the residential and other important areas. Mainly the areas where the diplomates and ambassador dwells in. In residential areas the fare is on limited range while the others have no limitation of fare range as well as the areas, cause these rickshaws have to authority to run outside the selected area. Rickshaws are mainly used for covering the short distance or at the time when there is less restriction of time.

For larger distance or for encompassing a lager route mainly buses are used in Dhaka city. Travelling by the bus is convenient among young students and commuters, due mainly to the affordable fares and accessibility. Some of these buses even offer special discounts for university and college going students. But one cannot deny that extensive routes and numerous stoppages have always been a problem when travelling by the bus (Moumita, 2016). The number of busses are increasing due to cope with the increasing number of the people in the Dhaka city. The bus companies of private ownership launch a good number of busses both ac and non-ac in various routes to meet the demand of the people. In Dhaka there are several types of buses running on the roads. Buses in Dhaka city have been categorized in several parts in 2004 by STP (Strategic Transport Plan) like minibuses (41%), microbuses (30%), large buses (13%), auto tempo/auto maxi (12%), and staff and school buses (4%). Normally the bus system has been understood by the inhabitants of the Dhaka city like ticket bus, local bus and tempos. Mainly ticket buses have fixed route and stoppages located by the ticket counters of the respective companies. Nowadays a significant number of minibuses are operated as ticket buses. On the other hand, local buses stop at numerous places and the system of fare collection is on board. They can collect passengers form any place of the road and mainly over crowded (Katz & Rahman, 2010). There are some specific routes of busses at which the regular passengers face some regular problems of immobilizing due to traffic jam. Overloading is very common in some of the bus services operated by authorities other than government.

Other than buses in Dhaka city CNG driven auto rickshaw has gained popularity because of the level of security for the users or passengers. Though there are some unwanted occurrences

regarding this mode of transport, it has minimized to a greater extant. The hassle of bargain is reduced because of fixed fare according to the distance.

Though there are some problems regarding to the public transportation, it is the main source of movement in Dhaka city without which it is near about impossible to gain contact with each other as well as their respective work places.

2.4 Importance of Comfort in Transportation

Comfort is considered as one of the top criteria of the passengers' satisfaction with the transportation services. It affects the customers satisfaction who have to use public transport for their daily purpose of travelling through the city or their respective work places (Eboli & Mazzulla, 2009). Normally people want to choose the mode of transport at which they feel more comfortable and which they can afford with in all of their constraints. Comfort is nowadays the measure of the quality of the system of transport for the people who are willing to use the specific mode and that's the reason why it is considered as a very important thing for the consideration of a public transport. While considering for introducing for the new mode of transport, the consideration of comfort is very important. Comfort is now directly considered as the proportion of the safety, because people consider themselves safer while they feel more comfortable in the chosen mode of transport.

In public transport, one of the major cause of not having the expected comfort is over crowding of the transport. Normally crowding refers to the physical phenomenon that is represented by high density of the people in vehicles, stops and access points (Tirachini et al., 2017). In vehicle crowding, travel time, and cost is one of the main important explanatory variable of mode choice of the people. For public transport modes high levels of crowding can results in physical discomfort, psychological burden, perceived risk and insecurity (Cox et al., 2006; Cheng, 2010; Mahudin et al., 2012). Moreover, crowding have an important effect on the level of service and the optimal choice of fare as well as mode of transport (Tirachini et al., 2014). Crowding is a common phenomenon in various cities and in city like Bangladesh it is one of the common and main reason of discomfort in public transportation. In the study of ours the main focus is to measure the comfort of the people in different mode of transports so that it can be used in different study

further for the better execution of the new proposed roads. It is the key variable in research on user acceptance of transportation systems.

A state of feeling which affects the reaction as well as the situation experienced by persons, known as comfort (Richards et al., 1978). Comfort is measured by the peoples' feedback of the situation of they have gone through. The situation is considered as the in-vehicle environment and this is a very important issue for the measurement of comfort. Comfort is now considered one of the main reason of choosing the mode of transports and this is playing a significant role in designing the road or introducing new mode on specific road for the passengers.

2.5 Measuring Comfort in Transportation Engineering

Comfort of the vehicle has developed a significant facet that are as significant as safety and speed in accessing the physical characteristics of transportation (Prashanth et al., 2013). The in-vehicle vibration and road roughness cause a predominant role in ride comfort as well as activity comfort. The quality of life on board vehicle in influenced by the level of ride comfort.

Various studies about measuring the comfort of the public transportations and each one of the study has been taken place by following only one means, either by mechanical way or by subjective way. No study has been taken place by using both of the mechanical and subjective way, but in our study both the mechanical and subjective ways have been used. In mechanical approach various instruments have been used in various studies. One way of this type of approach is participatory phone sensing. It is a new sensing paradigm that asks volunteers to contribute their phones' sensing capabilities and gather, analyze, and share local knowledge about their surroundings. Most existing participatory phone sensing systems are standalone structures without cross-system integration (Lin et al., 2011). For this the Comfort Measuring System (CMS) has been provided which consists of GPS and 3 axis accelerometer function of modern smart phones to measure the comfort level of vehicle rides. In example of various studies, it includes studies where only used the microphone and accelerometer of smart phones to infers users' activities and social context (Miluzzo,2008.). Where in another study Sound Sense machine learning technique has been used to measure the sound pressure level among the individuals (Lu et al., 2009.). In one study it has been proposed ambient information like microphone, camera, accelerometer, and Wi-

Fi to classify the location of a mobile phone (Azizyan et al., 2009.). Mobile smart phones have been employed for rich monitoring of road and traffic conditions via an array of sensors and communication radios for measuring the comfort of the targeted transportation modes (Mohan et al., 2008.). However, in all these studies the applications of the mechanical approach were standalone systems without cross-domain knowledge and cross-system integration. As a result, they cannot provide a large scale transportation system as a whole.

Control of vehicle vibration due to pavement roughness and road irregularities is an important element of achieving the quality in a road network. Measuring the Whole-Body Vibration (WBS) is one of the way to achieve the comfort limits in roads and in vehicle. In this method the comfort is measured through an index known as the international roughness index (IRI) (Cantisani and Loprencipe, 2010.). Roughness related problem has been highly increased in the recent times for measuring the comfort in modes or transports. Road pavement roughness is an expression of the surface irregularity and includes both localized and diffuse unevenness. It is the reason which causes vibration phenomena on the user's whole body during vehicle motion and usually reduces the ride quality means the reduction of the level of comfort in transports for the users. The factors that are directly or indirectly connected with the level of comfort have been measured by mechanical calibrated model which represented the dynamics of the vehicles on an uneven surface. In this study a prototype has been made by the researchers by which the data was collected, in this prototype the accelerometer has been used and by that data vibration has been found. The prototype is capable of collecting various kinds of data at a single time like temperature, acceleration, gyroscopic data, GPS data, sound.

Apart from the mechanical approach, subjective approach has also been used in various studies. Some studies have only conducted by using questionnaire survey. In different cities of the world this method has been used to collect data directly from the people who are using various kinds of transports as well facing various kinds of difficulties. There is diverse factor which disturbs the passengers and diminish the level of comfort. Noise and vibrations generated from the bus itself is one of the main reason of discomfort of the passengers. Questionnaire survey has been made to evaluate the comfort in transports conducting with the passengers (Narayanamoorthy et al., 2008). For estimating vibration comfort the analysis of road comfort parameters like International Roughness Index (IRI), and their correlation with kurtosis and the Vibration Dose Value (VDV)

have been used (Nahvi et al., 2009.). In questionnaire approach the passengers were given to some questions to answer while riding in public transport and then their responses were considered and analyses for the measurement of comfort. In this study a set of questions has been made to collect data from the passengers directly and analyzed to measure the comfort level of the transport.

Chapter 3
METHODOLOGY

3.1 Introduction

This survey intends to attain data from both questionnaire survey and physical parameters measurements conducted on buses, rickshaws, auto, AC buses and Auto concerning the comfort depending on sound, temperature, speed and vibration (identified variables). Each vehicle trip was recorded using subjective approach and a mechanical Arduino device.

The subjective approach was operated by a questionnaire, created from scratch based on the most significantly impacting parameters (identified variables). The mechanical data was obtained in the form of decimal values, in excel sheet. We treated both sets of data with an ANOVA test (single factor) to find the significance of the selected modes on the identified variables i.e. overall traffic comfort.

This kind of correlation of subjective and mechanical data is a pioneering step in the transportation field of a developing country like Bangladesh. Previously, comfort data was collected and worked upon by various researchers in Bangladesh, mainly in Dhaka. But the data collection process was either a questionnaire (subjective) or a mechanical process.

This survey although is a first timer for our country, it is just a basic research; it doesn't duplicate the comfort values for the entire Dhaka. To get a more precise result we must collect data from more than two routes. A correlation of those data would obviously lead our study to a valuable finding.

3.2 Identification of variables

The first step to the survey was finding out the major impacting comfort parameters. We used a basic survey to understand the importance of a list of impacting variables (e.g. speed, vibration, sound, temperature, air speed, weather impacts, transport quality, seat quality, service quality etc.)

We used a P value significance test with some of the above data. We used those P values to nullify some of the aforesaid variables, and let us with 4 significant impact variables.

They were-

1. Speed
2. Vibration
3. Sound
4. Temperature

For the subjective approach, we used a scale of measurement from 0 to 2 for speed, vibration, sound, temp; Here 0 being comfortable, 1 being uncomfortable, 2 will be extremely uncomfortable. We used a second temperature reading depending on the feeling (hot or cold). The range was taken from -2(very cold) to +2(very hot). We also attached an Overall Comfort rating to the whole trip on the same scale as the above comfort parameters.

Table 3.1 Units of Variables

Variables	**Unit**
Sound	dB
Temperature	Degree C
Acceleration	m/(s^2)
Vibration	m/(s^3)

3.3 Equipment Development for Measuring Comfort

For the mechanical data, we used an Arduino board attached with a gyroscope, GPS, accelerometer, temperature meter. We used a sound sensor device to attain the sound values along the route every 2 minutes.

3.4 Study Area

Data was collected from 2 selected bus routes which traveled through the Dhaka city, from IUT, Gazipur to Motijheel via Abdullahpur, Banani, Mohakhali. The top criterion for selection of bus routes was that the traffic quality and conditions and the route natures must resemble the general traffic operation conditions in Dhaka.

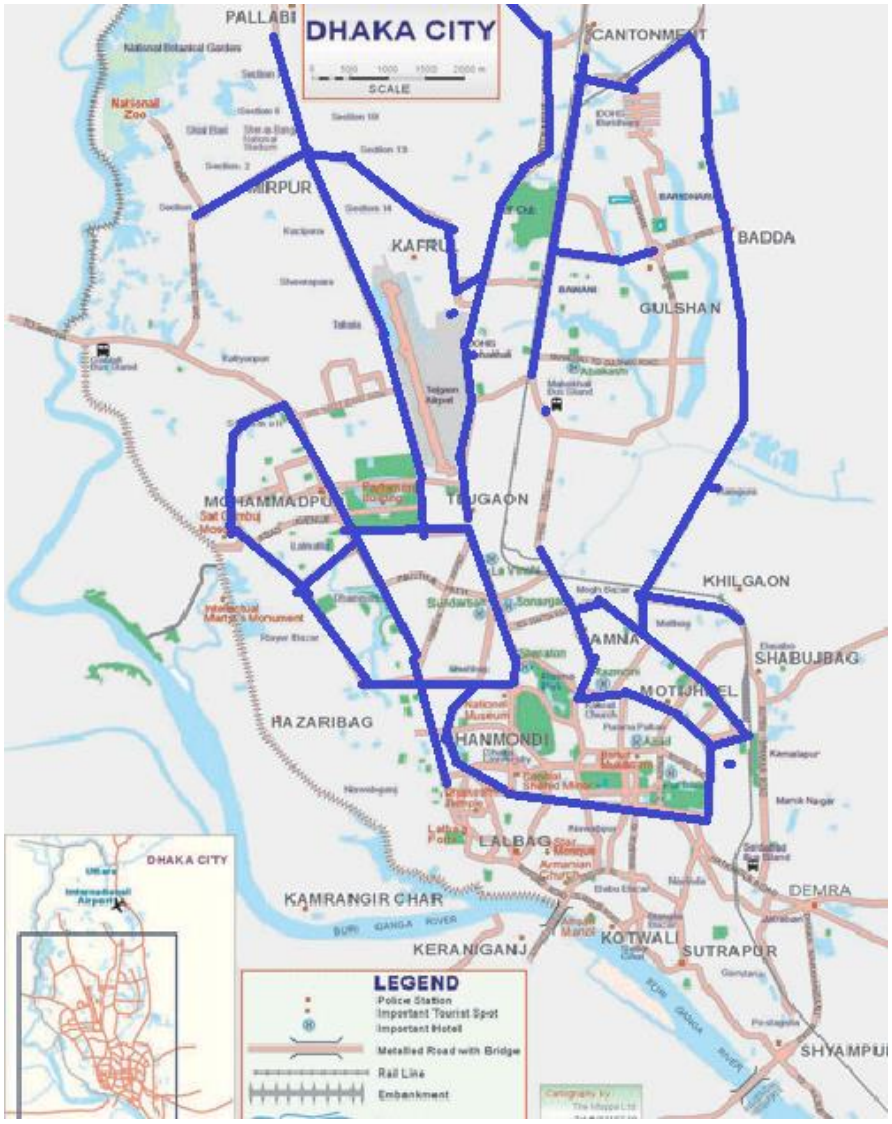

Figure 3.1 : Study Area

3.5 Survey Design

The physical parameters measurement and questionnaire survey commenced in September 2017 and was completed in the following month of October. A total of 200 were conducted (including

70 bus, 30 rickshaw, 30 auto, 50 AC bus, 20 Auto data). The questionnaire survey and mechanical measurement were conducted in between these journeys. There was a total of 200 passengers who completed the questionnaire (76% completed, 11% incomplete, 8% refused to participate, 5% cannot participate).

In this survey we considered both traditional non-AC buses and AC buses. By AC buses, we mean completed air-conditioned vehicle with limited access to outside environment. Typically, AC buses are supposed to be fully seated no standing vehicles, but in our case, there were different classes of AC buses which we tried to include in our data through commenting. By Autos, we meant the three wheeled automatic vehicles recently popular as a short distance public transport with a capacity of 8 people. By Auto we meant the typical medium distance public transport of nearly 16 people capacities, popular in central Dhaka city i.e. Farmgate, Mohammadpur etc.

In each mechanical measurement we got the data of GPS as a latitude and longitude data. We got speed in m/sec unit from the accelerometer. We also got the gyroscope data in three different formats (x axis, y axis, and z axis). We get the sound data as in decibels. We also stored the temperature data in Celsius. Air temperature was measured, while the radiant temperature was neglected. The parameter of clothing insulation was replaced. These measures were taken depending on the portability of the equipment and the duration of these face to face questionnaire survey on buses. The issue with the clothing insulation was not included in the questionnaire because it might take longer for the respondents to complete the whole survey. These might result in increase of the fraction of either incompletion or refusal of participation. To replace the parameter of the clothing insulation, the external/internal bus air temperature difference was measured in the analysis with the assumption that passengers would wear clothing dependent upon the ambient or seasonal condition in order to achieve the best thermal comfort. Furthermore, most passengers did not like the idea of taking off their outer layers but merely liked to unzip or unbutton their jackets on the buses. The radiant temperature was not included in the study because the equipment took such elongated response time values that the readings may not accurately reveal the transient condition, it was replaced with the air temperature.

The face to face survey was concerned with the particular participants' subjective responses towards the simultaneous in-vehicle thermal and other comfort issues. We used a 0 to 2 rating system with 0 being comfortable and 2 extremely uncomfortable.

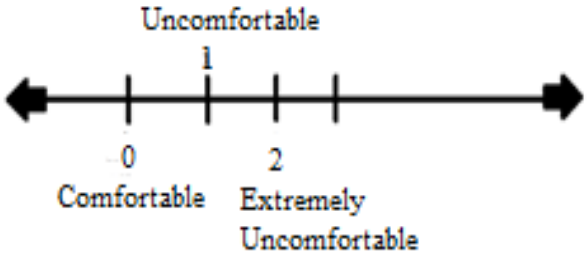

Fig 3.2: Comfort rating for subjective questionnaire for this study.

We used a different rating system for the measurement of feeling of temperature (hot and cold). Our approach toward the general was quite random, we took turns and picked randomly. Though a fraction of bias will always remain in such a physical approach in a conservative country like Bangladesh, since we could not target totally illiterate mass as much as the slightly modern mass. The ratio of that huge mass is thus little in our studies. And most of the time, in a tight packed morally draining physically depleting environment, people of a slightly lower class are not interested in participating with our survey. It is either from their lack of knowledge and hence acknowledging this as a vain work, or from over interest where their answers get overly biased.

We had limited access towards female passengers, as it is a morally challenging work in an environment like Dhaka city to confront female passengers with such surveys. We had to be really tactical with the approach, we took surveys of those females who were with another male, which would result in two data. The whole survey with any participant would contain certain questions so that we can mark down the comfort concerning the related parameter. There were questions about the sound quality, speed comfort, jerking effect, temperature comfort and feeling. The overall survey would always complete with an overall journey rating by the passenger. This rating would be on a 3 point scale. Here 0 would be very comfortable and 2 would be extremely uncomfortable.

QUESTIONS MADE FOR COMFORT QUALITY ANALYSIS RESEARCH IN TRANSPORTATION (QUESTIONNAIRE QUESTIONS):

1. How you will rate acceleration condition of the transport?
2. How you will rate the noise condition of the transport?

3. How is the cooling system of the transport?
4. Rate the suspension condition of the transport?
5. While getting down and getting into the transport, are the transport stops adequately comfortable?
6. How is the speed of the transport?
7. How frequently does the transport change its lane?
8. How is the traffic condition of the transport's prefixed route?
9. What is the load factor of the transport? (Here, Load Factor = number of passenger/total capacity)
10. What is in vehicle time for the journey?

3.6 Comparing Various Components of Comfort for Various Public Transportations

Lastly, with all the data from both subjective approach and Arduino data we will create a function of correlation. For example, in an AC Bus, our data directs us to a finding that Sound values in decibels ranging from 0-60 in a rough average gives a comfortable sound feeling, whereas 61-75 roughly sounds uncomfortable and over 75 decibels are just over the top. We tried to present a model of such correlation for further instances here.

Comfort Range for AC Bus:

Table 3.2 Comfort Range for Bus

Parameter	Comfortable (0)	Uncomfortable (1)	Extremely Uncomfortable (2)
Sound (dB)	0 - 60	61-75	>75
Temperature (°C)	22-26	27-32	>33
Speed (km/hour)	>40	11-39	0-10
Vibration (m/sec^3)	0-1.5	1.5-5	>5

The one-way analysis of variance (**ANOVA**) is used to determine whether there are any statistically significant differences between the means of three or more independent (unrelated) groups. In this study, we used ANOVA test to get a better understanding at the significance of impacting variables. Here the null hypothesis is taken to be such that the mean variance remains same among various modes for a particular factor.

Our findings will direct us to a more reliable comfort model of various modes of Dhaka city with a strong correlation between a subjective inquisition and a mechanical extraction of transport data. This could also direct us to understand the basic needs of Bangladeshi mass people regarding transportation, and we could find a clearer definition of comfort from the perspective of Bangladeshi passengers.

Chapter 4
ANALYSIS & RESULT

4.1 Introduction:

We have used both Subjective and Mechanical Approach for comparing comfort. For Subjective approach we collected responses given on the Android App from the local storage disk of phone. We collected various measurements from Arduino in Excel file format. Then we make relationship between data obtained by Arduino and passengers response. We calculated for which range people considers a trip comfortable, uncomfortable or extremely uncomfortable. When passenger finds a transportation mode as comfortable he scores it point 0, when the passenger finds the transportation mode as uncomfortable he scores it 1, when the passenger finds it extremely uncomfortable, he scores it 2.

4.2 Descriptive Statistics of Data:

Passengers responded differently in different conditions, locations, times of different modes of transports. For all the conditions mean value of response is calculated for particular variable. Then this mean value indicates the overall response of comfort for that particular vehicle. The maximum value of response of all 4 variables can be 8. As response values are considered 0,1,2. So maximum response value for 4 variables = 2+2+2+2=8. Lowest value is =0+0+0+0=0. The higher the overall response value indicates more uncomfortable condition and lower the response value indicates more comfort value. In this range 0 indicates Most Comfortable response & value 8 indicates worst comfortable response.

At the same time, we have made range of comfort levels regarding for variables. Such as if passengers responded speed 30 to 60 km/hour as response value 1 for a particular mode of transport such a AC Bus, we concluded that 30 to 60 km/hour speed level is regarded as comfortable range for passengers in AC bus. If for speed of 0 to 10 km/hour, passenger responds it as response value 2, it indicates that this range of speed has to be considered as Extremely Uncomfortable for passengers of that particular mode of transport such as AC Bus.

This is how we have calculated overall comfort regarding response for all the modes of transport as well as have found out the 3 comfort ranges (Comfortable, Uncomfortable & Extremely Uncomfortable) for 5 transportation modes (AC Bus, Non-AC Bus, Private Car, Auto & Rickshaw) & for 4 variables (Speed, Temperature, Vibration & Sound). Overall, we have found out 48 ranges of comforts considering different variables.

Below overall comfort regarding responses & comfort ranges for all the transportation modes are given with related data one by one-

For AC Bus:

We have collected data for sound ,temperature ,speed & vibration by Arduino and collected corresponding comfort rating from passengers .We have collected data for AC buses of BRTC .Its strating point is Uttora .

Table 4.1 Data for AC-Bus

		Sound		**Temperature**		**Speed**		**Vibration**	
Time	Location	Value (dB)	Rating	Value (degree)	Rating	Value (km/hr)	Rating	Value m/s^3	Rating
2.40 PM	Uttora	75	1	25	0	0.02	2	0.16	0
2.54 PM	Airport	75	2	25	0	0.35	2	0.75	0
3.20 PM	Bonani	74	1	26	0	0.11	2	1.87	1
3.47 PM	Jahangirgate	74	1	25	0	0.185	2	0.38	1
4.01 PM	Kawranbazar	73	1	33	2	38.18	1	3.1	2
4.11 PM	Shahbag	74	1	34	2	38.37	1	0.35	0
4.15 PM	Pressclub	73	1	34	2	60	0	0.58	0
4.22 PM	Motijheel	72	1	35	1	64	0	3.57	2
8.03 PM	Pressclub	72	1	32	1	16	1	1.96	1
8.32 PM	Shahbag	76	2	32	1	24	1	2.87	2
8.50 PM	Shahbag	65	1	32	1	18	1	0.052	0
9.50 PM	Kawranbazar	66	1	32	1	22	1	0.17	0
10.00 PM	Jahangir Gate	66	1	32	1	56	0	0.381	0
10.05 PM	Bonani	66	1	31	1	0.027	2	2.47	2
10.18 PM	Airport	66	1	31	1	3.32	2	0.57	0
6.16 PM	House Building	66	0	26	0	23	1	0.012	0
6.25 PM	Rajlokkhi	63	2	25	0	44	1	2.8	2

6.46 PM	Airport	72	1	25	0	56	0	1.05	1
6.52 PM	Khilkhet	74	1	22	0	10	2	1.65	1
7.15 PM	Mohakhali	84	2	28	1	0.87	2	0.200	0
7.50 PM	Farmgate	83	2	29	1	3.34	2	3.78	2
8.10 PM	Banglamotor	60	0	29	1	1.32	2	0.65	0
8.17 PM	Shahbag	72	1	29	1	8.98	1	1.52	1
8.22 PM	Romona Park	62	0	31	1	19.78	1	4.2	2
8.30 PM	Motshovhobon	81	2	32	2	5	1	2.068	2
8.45 PM	Press club	78	1	32	2	52	0	1.58	1
8.50 PM	Polton	77	2	33	2	2.3	2	1.633	1
8.54 PM	Gulistan	77	1	32	1	14	1	0.08	0
8.57 PM	Baitul Mokarom	83	2	33	2	0.78	2	.1.42	1
9.10 PM	Motijheel	78	1	31	1	32	1	0.07	0
Average		72.56	1.16	29.87	0.96	20.46	1.23	1.51	0.93

Overall Comfort regarding response for AC bus = 1.17+.97+1.23+.93=4.30 (Among 0-8 range)

Comfort Range for AC Bus:

Table **4.2** Comfort Range for Bus

Parameter	**Comfortable**	**Uncomfortable**	**Extremely Uncomfortable**
	0	**1**	**2**
Sound (dB)	0 - 60	61-75	>75
Temperature (°C)	22-26	27-32	>33
Speed (km/hr.)	>40	11-40	0-10
Vibration	0-1.5	1.5-5	>5

For Non-AC Bus:

Table 4.3 Data for Non-AC Bus

TIME	LOCATION	SOUND		TEMPERATURE		SPEED		VARIATION	
		Value (dB)	Rating	Value	Rating	Value (km/hr.)	Rating	Value m/s^3	Rating
4:39 PM	Bastura	75	2	39	2	40	1	1.32	1
7:51 PM	House building	70	2	39	2	20	2	2.11	2
8:25 PM	Bissoroad	73	2	38	2	10	2	0.28	1
9:25PM	Mirpur 10	72	1	38	2	39	1	0.38	1
7:35 AM	Adabar	66	1	33	1	45	1	1.45	1
8:00 AM	Taltola	70	2	33	1	40	1	6.11	2
8:18 AM	Mirpur 10	71	2	33	1	10	2	0.78	1
8:37	Purobi Haal	71	2	34	1	35	2	2.48	2
8:47 AM	Teker Bari	70	2	34	1	34	2	2.66	2
4:50 PM	Rajlokhhi	67	2	34	1	35	2	2.63	1
5:00 PM	Airport	70	2	34	1	40	1	2.53	2
5:07 PM	Bissoroad	66	2	34	1	44	1	4.54	2
5:15PM	ECB Chattar	70	2	34	1	30	2	2.32	2
3:20 PM	Kalshi more	65	2	37	2	45	1	1.53	1
3:32 PM	Mirpur 10	72	2	37	2	0.78	2	6.4	2
3:47 PM	Taltola	68	2	37	2	49	1	1.76	1
6:00 PM	College Gate	69	2	36	2	50	1	3.23	1
6:10 PM	Shamoli			36	2	15	2	1.27	1
4:43PM	House building	70	2	36	2	50	1	2.78	1
4:57 PM	Airport	68	2	36	2	10	2	1.9	2

5:07 PM	Bissoroad	68	2	36	2	65	0	1.7	1
5:23 PM	Banani	69	2	36	2	40	1	2.3	1
5:38 PM	Jahangir gate	70	2	36	2	30	2	2.7	1
7:08 PM	Jamuna Future	68	2	39	2	20	2	1.1	0
7:22 PM	Khilkhet	72	2	39	2	32	2	1.6	1
7:27	Airport	67	2	39	2	35	2	0.78	0
7:45 PM	House building	68	2	39	2	10	2	2.7	1
8:00 PM	Station Road	68	2	39	2	20	2	2.6	2
8:20 PM	Cherag Ali	70	2	39	2	16	2	1.7	1
8:30 PM	Boro Bari	70	2	39	2	30	2	0.65	0
8:37 PM	Board Bazar	70	2	39	2	32	2	0.68	0
Average		69.4	1.93	36.51	1.70	31.34	1.58	2.18	1.2

Overall Comfort regarding response for Non-AC bus = 6.41 (Among 0-8 range)

Comfort Range for Non-AC Bus:

Table **4.4** Comfort Range for Non-AC Bus

Parameter	Comfortable (0)	Uncomfortable (1)	Extremely Uncomfortable (2)
Sound (dB)	0-60	61-75	>75
Temperature (°C)	22-29	30-40	>40
Speed (km/hr)	>40	11-40	<10
Vibration (m/sec^3)	0-1	1-2	>2

Overall Comfort regarding response for Non-AC bus = 4.57 (Among 0-8 range)

For Rickshaw:

Table **4.5** Data for Rickshaw

TIME	LOCATION	SOUND		TEMPERATURE		SPEED		VARIATION	
		Value (dB)	Rating	Value	Rating	Value (km/hr.)	Rating	Value m/s^3	Rating
4:39 PM	Gabtoli	62	1	39	2	2.4	2	4.12	2
6:10 PM	zigatola	68	1	35	1	14	1	0.059	0
4.30 PM	baily road	60	1	40	2	7.29	1	0.51	2
9:25PM	Station Road	69	1	38	0	2.38	2	0.072	2
9:45 AM	Diya Bari	54	0	33	1	25	0	0.82	1
8:18 AM	Bottola	55	0	32	0	27	0	1.1	1
8:37	Purobi Hall	74	2	34	1	0.21	2	3.52	2
9:00 AM	kalshi	62	1	28	0	23	0	1.6	0
3:40 PM	mirpur 2	70	2	35	2	15	1	1.34	1
4:05 PM	boshundhora R/A	64	1	35	1	17	0	2.32	2
4:37 PM	Gulshan	72	2	35	2	2.2	2	1.76	1
5:15PM	BoardBazar	69	2	34	1	3.76	1	1.98	2
5:35 PM	Chourasta	68	1	35	1	25	1	1.32	1
5:50 PM	College Gate	67	1	33	1	7.8	1	2.98	2
Average		65.2	1.14	34.71	1.07	12.28	1	1.67	1.35

Comfort Range for Rickshaw:

Table **4.6** Comfort Range for Rickshaw

Parameter	Comfortable	Uncomfortable	Extremely Uncomfortable
	0	1	2
Sound (dB)	<60	60-70	>70
Temperature (°C)	<32	33-36	>36
Speed (km/hr.)	20-30	3 to 20	0-3
Vibration	0-.6	.6-2	>2

(m/sec^3)

Overall Comfort for Rickshaw = 4.51

For Auto:

Table **4.7** Data for Auto

Time	Location	Sound		Temperature		Speed		Vibration	
		Value (dB)	**Rating**	**Value** (degree)	**Rating**	**Value** (km/hr.)	**Rating**	**Value** m/s^3	**Rating**
2.40 PM	RingRoad	86	2	36	2	6	1	2.78	1
2.54 PM	KamarBari	68	2	31	2	3.79	1	0.15	2
3.20 PM	New Market	69	1	38	2	2.31	2	0.101	0
3.47 PM	Jahangirgate	74	1	35	2	0.185	2	0.38	1
4.01 PM	Shamoli	73	2	33	1	27	1	3.28	2
4.11 PM	Kollanpur	59	0	34	2	56	0	4.21	2
4.15 PM	Technical	69	1	34	2	60	1	0.78	1
2.22 PM	Mirpur 1	85	2	36	2	2.54	0	3.48	2
3.03 PM	Mirpur 10	83	2	36	2	0	2	1.39	1
3.32 PM	Mirpur 11	76	2	35	1	24	1	1.63	1
3.50 PM	Mirpur 12	77	1	35	1	2.1	2	1.53	1
9.50 PM	Newmarket	66	1	31	1	1.03	2	1.54	1
10.00 PM	Science Lab	66	1	32	1	0	2	1.32	2
10.05 PM	Jigatola	65	1	31	1	0.027	2	3.53	2
10.18 PM	Mohammadpur	66	1	30	1	32.32	1	2.4	2
6.16 PM	Siya Mosjid	76	2	33	1	7.8	1	3.76	2
Average		72.3	1.3	33.7	1.5	14.04	1.3	2.01	1.4

Comfort Range for Auto:

Table **4.8** Comfort Range for Auto

Parameter	Comfortable	Uncomfortable	Extremely Uncomfortable
	0	1	2
Sound (dB)	0 - 60	61-75	>75
Temperature (°C)	<30	31-35	>35
Speed (km/hr)	>35	3 to 35	0-3
Vibration (m/sec^3)	0-1.20	1.2-3	>3

Overall Comfort regarding response for Auto= 5.65 (Among 0-8 range)

For Private Car:

Table **4.9** Data for Private Car

		Sound		Temperature		Speed		Vibration	
Time	**Location**	**Value (dB)**	**Rating**	**Value** (degree)	**Rating**	**Value** (km/hr)	**Rating**	**Value** m/s^3	**Rating**
2.40 PM	Uttora	62	1	22	0	0.02	2	0.72	1
2.54 PM	Airport	66	1	23	0	18	1	0.67	1
3.20 PM	Bonani	48	0	34	1	52	0	0.87	1
3.47 PM	Jahangirgate	65	1	25	0	62	0	0.38	0
4.01 PM	Kawranbazar	73	2	33	1	65	0	1.5	2

4.11 PM	Shahbag	69	1	28	1	38.37	1	1.1	1
4.22 PM	Diyabari	47	0	23	0	80	0	0.71	1
8.03 PM	Ashulia	51	1	23	0	67	0	0.45	0
8.32 PM	Kalshi	66	1	29	1	40	1	0.36	0
8.50 PM	Shamoli	82	2	32	1	55	0	1.29	1
9.50 PM	Mohammadpur	51	0	32	1	22	1	0.76	1
Average		62.75	0.91	28.16	0.66	46.61	0.5	0.79	0.83

Comfort Range for Private Car:

Table **4.10** - Comfort Range for Private Car

Parameter	**Comfortable**	**Uncomfortable**	**Extremely Uncomfortable**
	0	1	2
Sound (dB)	0 - 60	61-70	>71
Temperature (°C)	20-25	26-34	>34
Speed (km/hr.)	>45	15-45	0-15
Vibration (m/sec^3)	0-.5	.5-1.5	>1.5

Overall Comfort regarding response for Private Car= 2.92 (Among 0-8 range)

In this way we have calculated various ranges of comfort for 5 modes of transportation considering 4 variables. Comfort level changes with transportation. To statistically test this fact, we have conducted Single Factor Anova Test. Here the null hypothesis is considered as mean variance

remains the same between various modes of transport for a particular factor such as Speed or any of the four.

For Sound Factor in all modes of Transportation Modes:

Table **4.11** – ANOVA Test for Sound

SUMMARY

Groups	Count	Sum	Average	Variance
AC Bus	30	2177	72.56667	40.87471
Non-AC Bus	30	2083	69.43333	4.805747
Rickshaw	14	914	65.28571	36.37363
Private Car	16	1158	72.375	60.38333
Auto	12	753	62.75	126.2045

ANOVA

Source of Variation	SS	df	MS	F	P-value	F criteria
Between Groups	1209.753	4	302.4382	7.169951	0.000042	2.46548
Within Groups	4091.59	97	42.18135			
Total	5301.343	101				

Here, for sound factor F value (7.16) is more than F critical value (2.465). So, for sound factor, Null Hypothesis is rejected. That means there is significant variation between transportation groups for sound factor .

For Temperature Factor in all modes of Transportation Modes:

Table **4.12** – Anova Test for Temperature

Groups	Count	Sum	Average	Variance
AC Bus	30	896	29.86667	11.98161
Non-AC Bus	31	1132	36.51613	4.791398
Rickshaw	14	486	34.71429	8.989011
Private Car	16	540	33.75	5.266667
Auto	12	338	28.16667	22.69697

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	1007.792	4	251.948	26.35854	7.57E-15	2.464505
Within Groups	936.7324	98	9.558494			
Total	1944.524	102				

Here, for sound factor F value (26.35) is more than F critical value (2.465). So, for Temperature factor, Null Hypothesis is rejected. That means there is significant variation between transportation groups for sound factor.

For Speed Factor in all modes of Transportation Modes:

Table **4.13** – Anova Test for Speed

Groups	Count	Sum	Average	Variance
AC Bus	30	613.932	20.4644	447.9605
Non-AC Bus	31	971.78	31.34774	224.35
Rickshaw	14	172.04	12.28857	96.02341
Private Car	16	225.102	14.06888	403.1432
Auto	16	32.261	2.016313	1.83073

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	10422.61	4	2605.651	9.827459	9.15E-07	2.4608
Within Groups	27044.27	102	265.1399			
Total	37466.87	106				

Here, for speed factor F value (9.82) is more than F critical value (2.465). So, for Temperature factor, Null Hypothesis is rejected. That means there is significant variation between transportation groups for speed factor.

For Vibration Factor in all modes of Transportation Modes:

Table **4.14** – Anova Test for Vibration

Groups	Count	Sum	Average	Variance
AC Bus	30	42.00174	1.400058	1.546482
Non-AC Bus	31	66.97	2.160323	2.059243
Rickshaw	14	23.501	1.678643	1.495768
Private Car	16	32.261	2.016313	1.83073

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	9.768671	3	3.256224	1.845172	0.144926	2.709402
Within Groups	153.5312	87	1.764726			
Total	163.2999	90				

Here, for Vibration Factor F value (1.85) is more than F critical value (2.70). So, for Vibration factor, Null Hypothesis is not rejected. That means there is not significant variation between transportation groups for vibration factor.

4.3. Comfort in Various Public Transportations

We have finally come to know in Dhaka city among 5 public transportation modes which one overall gives most comfortable journey experience. We have ranked transportation modes according to their comfort level. Overall comfort range for transportation modes:

Table **4.15** Comfort Range

Comfortable	0-2
Uncomfortable	3-5
Extremely Uncomfortable	6-8

The lower the value of overall comfort score, it will indicate more comfort. Higher value, it indicates more discomfort. Lowest value is 0 and highest value is 8. According to this range comfort ranking for 5 modes of transportation is given below-

Table **4.16** Comfort Ranking

RANK	Transport Type	Obtained Value	Comfort Level
1	Private Car	2.91	Comfortable
2	AC Bus	4.3	Uncomfortable
3	Rickshaw	4.57	Uncomfortable
4	Auto	5.63	Uncomfortable
5	Non-Ac Bus	6.41	Extremely Uncomfortable

Graphical Representation of comfort ranking is given below:

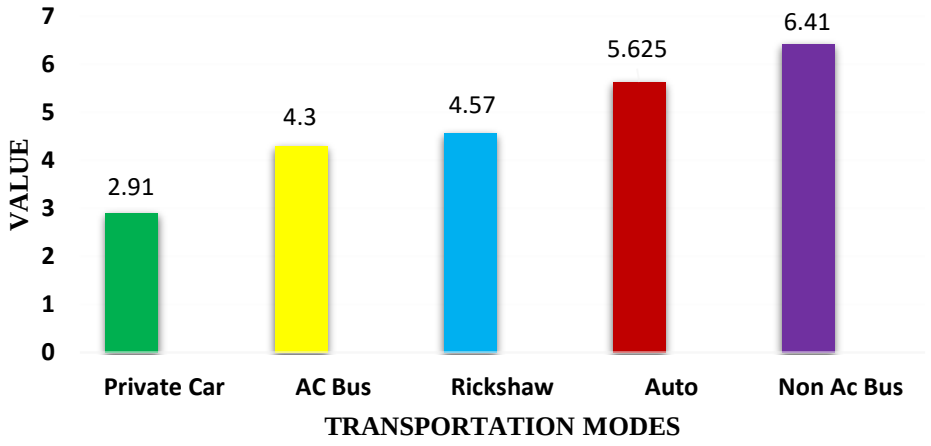

Figure **4.1** Graphical Representation of Comfort Range

Here from this chart we see, Private Car gives is most comfortable among other modes scoring only 2.91 among 0-8 scoring range. On the contrary, non-AC bus gives Extremely Uncomfortable journey experience scoring highest value of 6.41 among 8.0 score.

Speed variation in various modes of Transportation considering Arduino Based Speed Value:

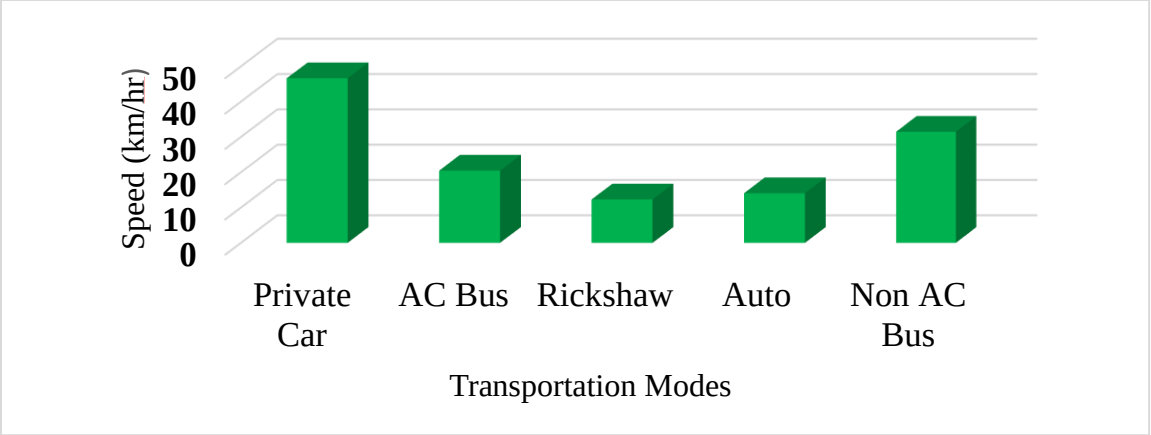

Figure **4.2** Graphical Representation of Speed in various modes

Here we can see, Private car gives higher value of speed among five modes. On the contrary, rickshaw has slowest speed value.

Comfort response variation in various modes of Transportation considering Speed:

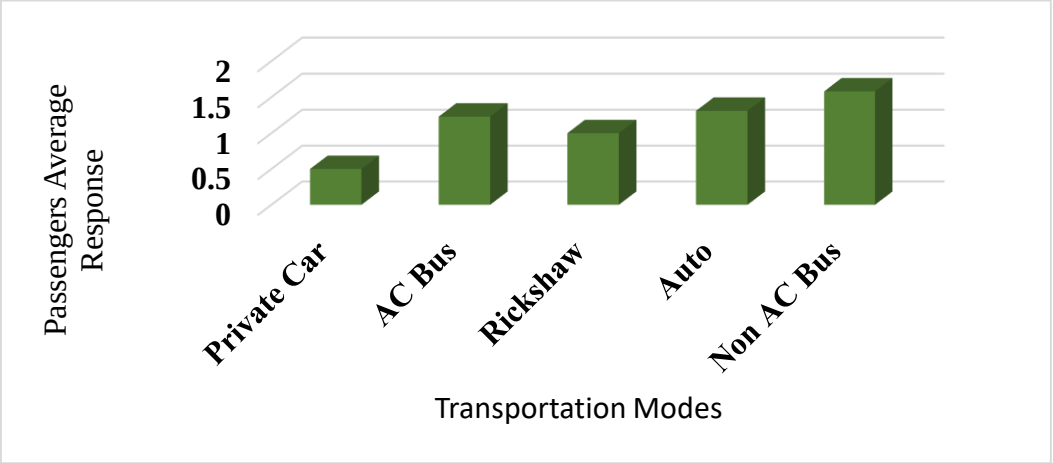

Figure **4.3** Graphical Representation of Speed Responses in various modes

Passenger scored, Private car as most comfortable one among other modes. Non-Ac Bus is considered as worst one regarding speed comfort .

Sound variation in various modes of Transportation considering Arduino Based Sound Value:

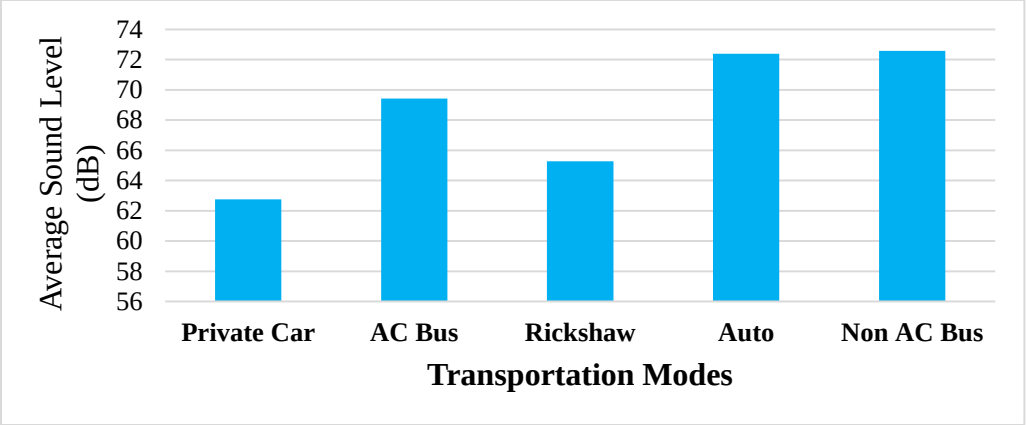

Figure **4.4** Graphical Representation of Sound in various modes

Here we can see, Non-AC bus has highest value of Sound Level. Private Car has lowest level of Sound.

Comfort response variation in various modes of Transportation considering Sound:

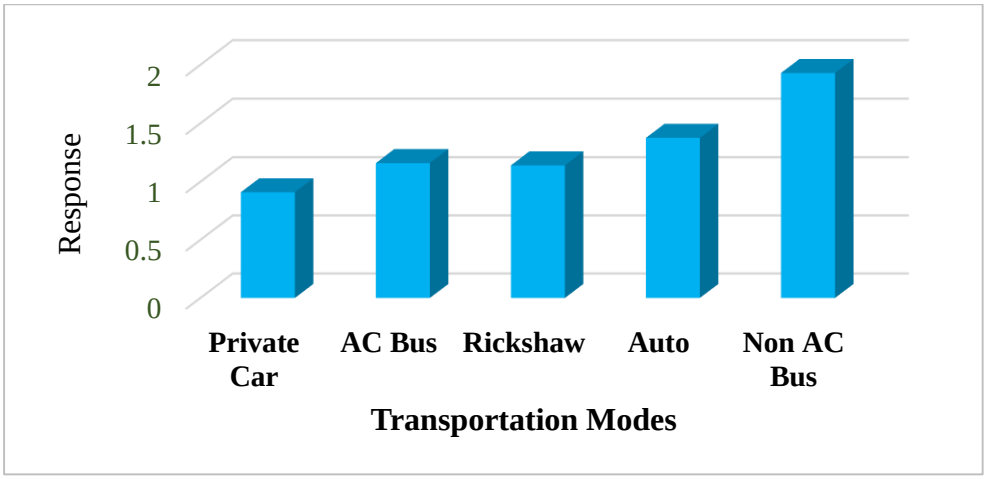

Figure **4.5** Graphical Representation of Speed Response in various modes

Passengers responded as private car being most comfortable regarding sound affect & non-AC bus most uncomfortable in this regard.

Temperature variation in various modes of Transportation considering Arduino Based Temperature Value:

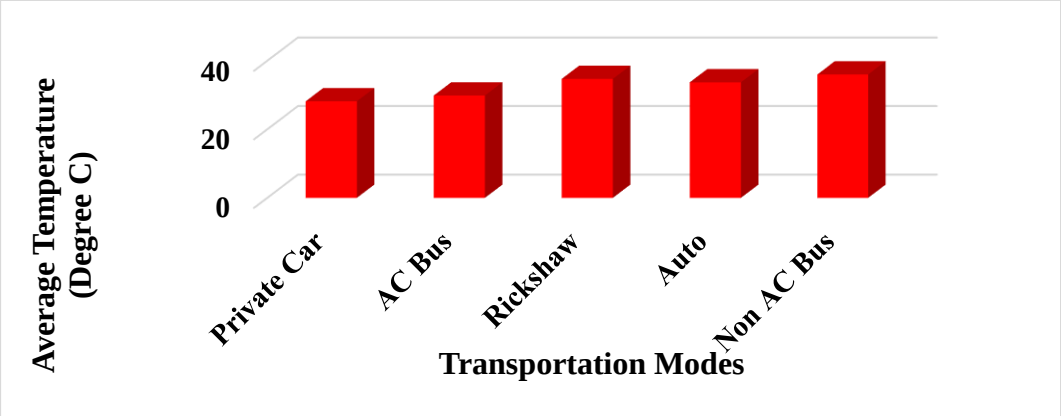

Figure **4.6** Graphical Representation of Temperature in various modes

Here we can see Private car maintains least temperature, then AC bus gives less Temperature. Both Non-AC bus and Rickshaw gives most high level of temperature.

Comfort response variation in various modes of Transportation considering Temperature:

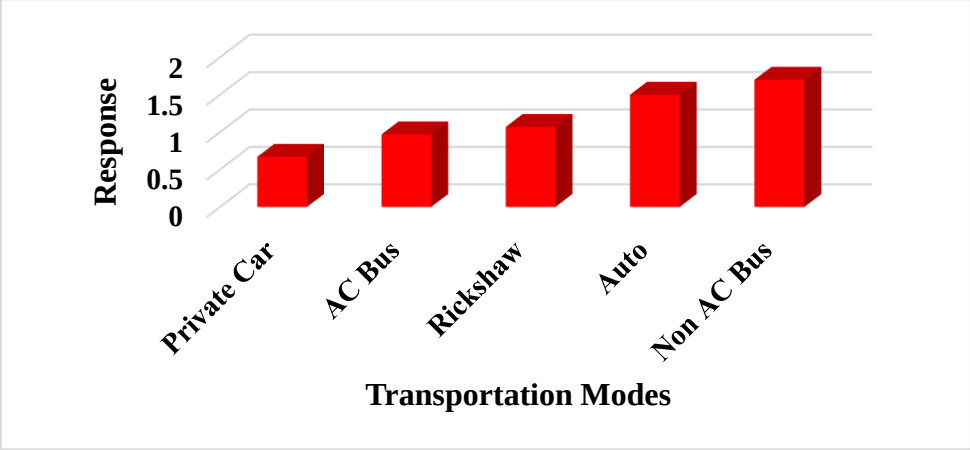

Figure **4.7** Graphical Representation of Temperature response in various modes

Passenger responded as Private car being most comfortable among all modes regarding Temperature and Non-AC Bus as the worst one for temperature

Vibration variation in various modes of Transportation considering Arduino Based Vibration Value:

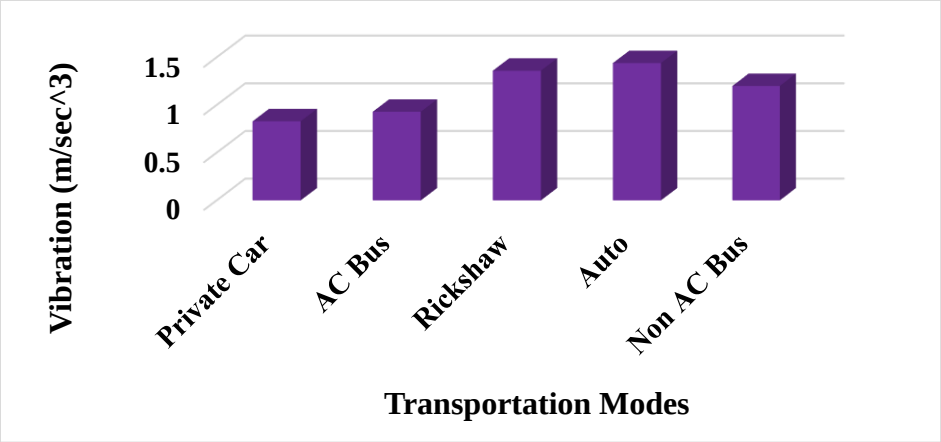

Figure **4.8** Graphical Representation of Vibration in various modes

Private car gives least value for vibration, on the contrary Auto gives highest range of vibration.

Comfort response variation in various modes of Transportation considering vibration:

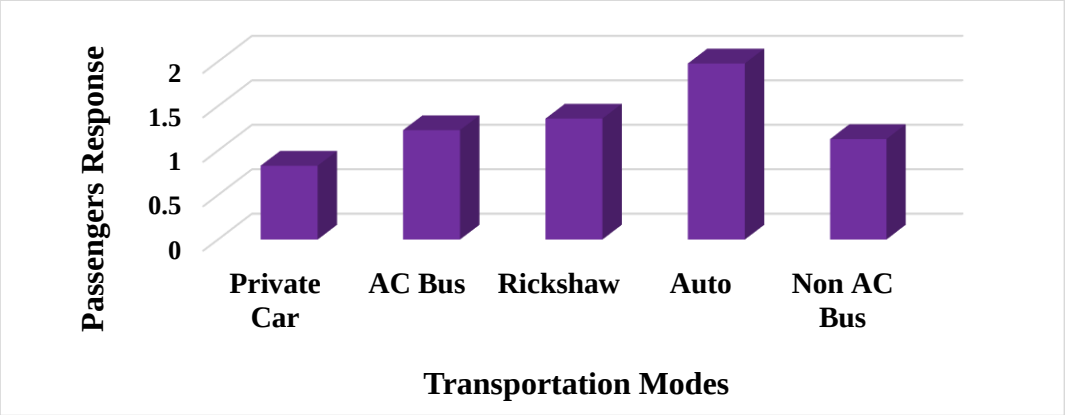

Figure **4.9** Graphical Representation of Response in various modes

Passenger responded Private car as most comfortable considering vibration. And responded Auto for worst comfort level regarding vibration

Chapter 5

CONCLUSION

5.1 Introduction

Studies related to estimation of comfort are done based on either questionnaire approach or mechanical approach. Neither of the previous studies has been done regarding comfort on various transportations modes in Dhaka City nor anyone has evaluated any comfort ranges for different variables. Our research is unique. Because -

- It's a new perception
- Combines both the subjective and mechanical approaches
- We have find out various comfort ranges both from human response and from Arduino measurements

5.2 Major Findings:

- We have ranked 5 most common transportation modes according to level of comfort in Dhaka City. According to our ranking, private car stands in the 1st position regarding overall comfort. AC Bus, Rickshaw, Auto, Non-AC bus have come in the rank respectively after private car. Among the five modes of transport, public non-AC buses are identified as most uncomfortable mode of transportation in respect to speed, temperature, vibration & sound. Though public non-AC buses are most common way of transportation for general people in Dhaka city, people are facing high discomfort in their day to day life travelling on it.
- We have evaluated the range of comfort in different transportation modes to find out at which level passengers feel comfortable while travelling
- From Single Factor ANOVA test we have come to know, there is significant mean variance between various modes of transportation. So, there are different ranges for same factor in different transportation modes.

5.3 Limitations:

- We have used only four types of Public Transports. Many other modes of transports such as Motor Bike, Two Stroke Motor Vehicle (i.e. CNG), Micro Bus, Mini Bus, Pajero, SUV, Trucks which we could not add to evaluate comfort analysis due to time and resource constraints.
- Our study is only based on surface vehicles. No Comfort analysis is done for air & water transports.

- We have used 3 ranges. Comfortable, Uncomfortable, Extremely uncomfortable. We could have more comfort ranges. Such as Highly Comfortable, Slightly Uncomfortable and many more. More comfort segment would give more comfort predictions.

5.4 Future Scopes:

- In future we can increase more types of transports for comfort analysis.
- In future we can analyze comfort considering more variables such as cleanliness, air quality, seat quality, spacing for legs, behavior of helper, driving skill of driver, security and many more.
- In implementation of new road design in Dhaka City, using our comfort values, suitable modes of transports can be introduced.
- For making a new design of any transport, how its acceleration, speed, temperature, interior sound should be, can be estimated from our comfort ranges for such variables.

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