Estimation of Bus Travel Time Reliability in Dhaka Area

Submitted By

Md.Sagor Ali

201-47-344

Montasir Mamun Hemal

201-47-349

Farhana Rahman Mili

201-47-367

Shakil Ahmed

201-47-370

Supervised By

Saurav Barua

Supervisor and Assistant Professor

Department of Civil Engineering

A Thesis submitted to the Department of Civil Engineering, Daffodil Internatinal University in partial Fulfillment of the Requirements for the Degree of

Bachelor of Science in Civil Engineering

DEPARTMENT OF CIVIL ENGINEERING

DAFFODIL INTERNATIONAL UNIVERSITY

June 2024

The Thesis titled '**Estimation of Bus Travel Time Reliability in Dhaka Area**' submitted by **Md.Sagor Ali (**201-47-344), **Montasir Mamun Hemal** (201-47-349)**, Farhana Rahman Mili** (201-47-367)**,Shakil Ahmed (**201-47-370) have been accepted as satisfactory in fulfillment of the requirement for the final presentation of CE-400 (Thesis) on 9th June 2024.

BOARD OF EXAMINERS

(Supervisor)

Saurav Barua

Assistant Professor, Department of Civil Engineering

Daffodil International University

(Chairman)

Dr. M.R.Kabir

Professor, Department of Civil Engineering

Daffodil International University

(Member 1)

Saurav Barua

Assistant Professor, Department of Civil Engineering

Daffodil International University

(Member 2)

Ahad Ullah

Sr.Lecturer, Department of Civil Engineering

Daffodil International University

(External)

Madani M. Imtiaz Hossain

Technical Director,GPH Ispat

APPROVAL

This is to certify that this project and thesis entitled "**Estimation of Bus Travel Time Reliability in Dhaka Area**" is done by the following students under my direct supervision and this work has been carried out by them in the Department of Civil Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Civil Engineering. The presentation of the work was held on 9th June 2024.

Saurav Barua

Supervisor and Assistant Professor

Department of Civil Engineering

Daffodil International University

DECLARATION

This is to certify that this project and thesis entitled "**Estimation of Bus Travel Time Reliability in Dhaka Area**" is done by the following students under my directsupervision and this work has been carried out by them in the Department of Civil Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Civil Engineering. The presentation of the work was held on 9th June 2024

Sagor

Md.Sagor Ali

201-47-344

Hemal

Montasir Mamun Hemal

201-47-349

Farhana

Farhana Rahman Mili

201-47-367

Shakil

Shakil Ahmed

201-47-370

ACKNOWLEDGMENT

At first, we want to thank almighty God. All glory belongs to the Almighty God who bestows patience and the capacity for hard effort, both of which led us to success and enabled us to successfully finish this thesis. We worked for this thesis under the supervision of our respected Saurav Barua, Supervisor and Assistant Professor, Department of Civil Engineering, Daffodil International University, oversaw us while we worked on our thesis. Thanks to his excellent and continuous direction, constructive criticism, and crucial support, ideas, and encouragement, we were able to successfully complete our thesis. Our needs were met by many, in different ways. We also extend our deepest appreciation to them.

Finally,We would like to express our gratitude to our parents for their continuous encouragement and guidance. Their financial and psychological assistance is essential to our ability to finish this study.

DEDICATION

This thesis dedicated to all of Our Family Members and teachers who inspired us for made this effort possible.

ABSTRACT

Having a growing population and increasing urbanization, Dhaka City has a lot of obstacles when it comes to keeping up a dependable and effective public transit system. With the goal of offering a comprehensive knowledge of the variables driving variability in bus travel times throughout the city, this thesis explores the crucial topic of bus travel time dependability. In order to do a thorough study, the research uses a complex strategy that integrates real-time data, historical trip time records, and sophisticated statistical modeling approaches. The study begins with a thorough analysis of the body of prior research, constructing a theoretical framework that outlines the critical components influencing the dependability of bus journey times in intricate urban settings. Then, in order to find patterns, trends, and causes of trip time variability, large datasets from the bus fleet of Dhaka City are examined. Next, predictive models are created using machine learning techniques, which enable the prediction of journey time reliability in a variety of operating and environmental scenarios. The study findings have noteworthy consequences for Dhaka City politicians, transportation authorities, and urban planners. The thesis aids in the creation of focused interventions and policies meant to improve the effectiveness of the city's bus transportation system by offering useful insights into the factors influencing bus trip time reliability. The results are anticipated to spark enhancements in service dependability, resulting in a rise in public confidence, ridership, and a more sustainable urban transportation environment. The study's methods and conclusions go beyond Dhaka to add to the larger body of knowledge on urban transportation planning by providing a repeatable framework for evaluating and enhancing bus service.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATION

Acronym	Definition
WMRA	Wednesday morning Rajlaxmi to Abdullahpur
WORA	Wednesday off-peak Rajlaxmi to Abdullahpur
WERA	Wednesday evening Rajlaxmi to Abdullahpur
TMRA	Thursday morning Rajlaxmi to Abdullahpur
TORA	Thursday off-peak Rajlaxmi to Abdullahpur
TERA	Thursday evening Rajlaxmi to Abdullahpur
FMRA	Friday morning Rajlaxmi to Abdullahpur
FORA	Friday off-peak Rajlaxmi to Abdullahpur
FERA	Friday evening Rajlaxmi to Abdullahpur
WMM2M10	Wednesday morning Mirpur 2 to Mirpur 10
WOM2M10	Wednesday off-peak Mirpur 2 to Mirpur 10
WEM2M10	Wednesday evening Mirpur 2 to Mirpur 10
TMM2M10	Thursday morning Mirpur 2 to Mirpur 10
TOM2M10	Thursday off-peak Mirpur 2 to Mirpur 10
TEM2M10	Thursday evening Mirpur 2 to Mirpur 10
FMM2M10	Friday morning Mirpur 2 to Mirpur 10
FOM2M10	Friday off-peak Mirpur 2 to Mirpur 10
FEM2M10	Friday evening Mirpur 2 to Mirpur 10
WMM14M10	Wednesday morning Mirpur 14 to Mirpur 10
WOM14M10	Wednesday off-peak Mirpur 14 to Mirpur 10
WEM14M10	Wednesday evening Mirpur 14 to Mirpur 10
TMM14M10	Thursday morning Mirpur 14 to Mirpur 10
TOM14M10	Thursday off-peak Mirpur 14 to Mirpur 10
TEM14M10	Thursday evening Mirpur 14 to Mirpur 10
FMM14M10	Friday morning Mirpur 14 to Mirpur 10
FOM14M10	Friday off-peak Mirpur 14 to Mirpur 10
FEM14M10	Friday evening Mirpur 14 to Mirpur 10
ATT	Average Travel Time
PI	Planning Time
BT	Buffer Time
BTI	Buffer Time Index
BI	Buffer Index
PTI	Planning Time Index

CHAPTER I

INTRODUCTION

1.1 Background of The Study

Bangladesh's main city, Dhaka, struggles with enduring and difficult traffic conditions that have come to represent the city's urban environment. The city, which is characterized by congested streets, a growing population, and fast urbanization, has many traffic-related problems. Due to the ever-growing number of cars on the roads which were initially built for a much lower population traffic is congested during peak hours. The issue is made worse by the absence of an extensive and effective public transit infrastructure, which forces a sizable section of the populace to depend on private automobiles. The resultant gridlocks not only cause aggravating delays for passengers but also raise environmental issues because of the increasing emissions. The introduction of mass transit systems, including the metro rail, as well as campaigns to support environmentally friendly forms of mobility are two ways that this problem is being addressed. But the road ahead is still difficult, necessitating a comprehensive and coordinated strategy to ease Dhaka's ongoing traffic problems. The accuracy of bus journey times in Dhaka city may be impacted by a number of variables as of my most recent knowledge update in January 2023, and things may have changed since then. The notoriously difficult traffic in Dhaka has a direct bearing on how predictable and dependable bus journey times are. While traffic is heavy during rush hour, it may cause delays and be difficult to predict how long a bus ride would take.

Figure 1-1:Abdullapur Bus Stand

Reliability is influenced by a number of factors, including the state of the public transportation system generally, timetable adherence, and road infrastructure. The goal of current initiatives like the Dhaka Metro Rail and the creation of dedicated bus lanes is to increase the effectiveness of public transportation and, in turn, the dependability of bus journey times. It's important to remember that the success of these programs may differ, and that the general dependability of bus travel times may be impacted by the city's continuous expansion, infrastructure modifications, and the use of thorough urban planning techniques. It is helpful to check with local transportation authorities, use real-time transit apps, or consult official sources that offer updated information on traffic conditions and public transportation schedules for the most up-to-date and precise information regarding the dependability of bus travel times in Dhaka.

When traffic is heavy during rush hour, it may cause delays and be difficult to predict how long a bus ride would take. Reliability is influenced by a number of factors, including the state of the public transportation system generally, timetable adherence, and road infrastructure. [1]

1.2 Concept of travel time reliability

Bus travel time is defined as the time needed by a bus to travel between two points along a route. Travel time reliability (TTR) is defined as the consistency in travel time over periods of the day or days of the week. This concept serves as a significant measure for delivering travelers about reliable route information, evaluating the operational efficiency of transportation facilities, and comparing different traffic management. In metropolitan Lagos, public bus travel time is presently unreliable and travelers have challenges getting to their destination on time. This study, therefore, adopts this concept as part of the basis for examining the travel time reliability of yellow buses in the study area. [2]

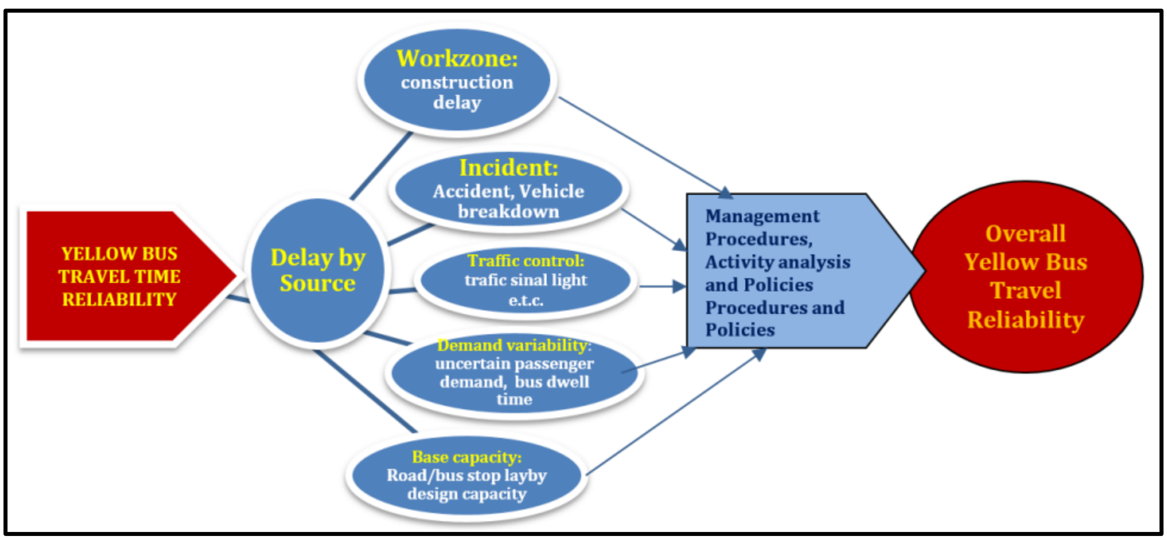


Figure 1-2:Research conceptual framework

1.3 The Importance of Reliability in Public Transport

The concept of reliability is used in various industries and is thus considered from many perspectives. According to T. Nowakowski [3] reliability consists of properties such as readiness and credibility (Figure 1-3) [4]

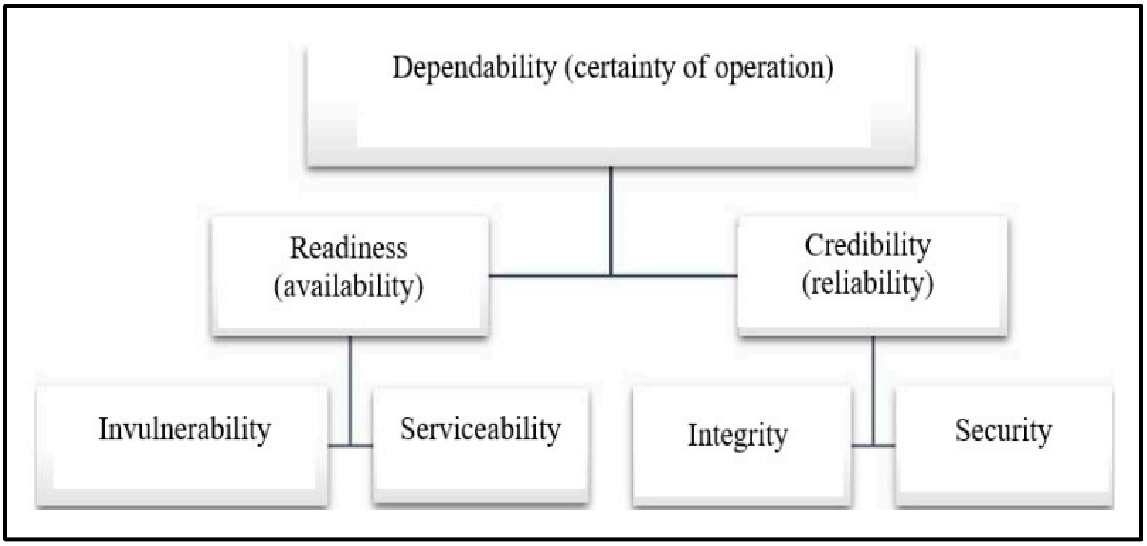


Figure 1-3:Diagram of the reliability concept hierarchy.

Among many users of the transportation system, including drivers of motor vehicles, transit users, freight shippers, and even air passengers, trip time reliability is important. Dependability is important to both leisure and business travelers because it lets them use their time more wisely. To be competitive, shippers and freight carriers need to have consistent trip schedules. On privately funded or run roadways, reliability is an important service that may be offered. Travel time reliability is a critical performance metric that transportation planners and decision-makers should consider due to its importance to users of the transportation system.

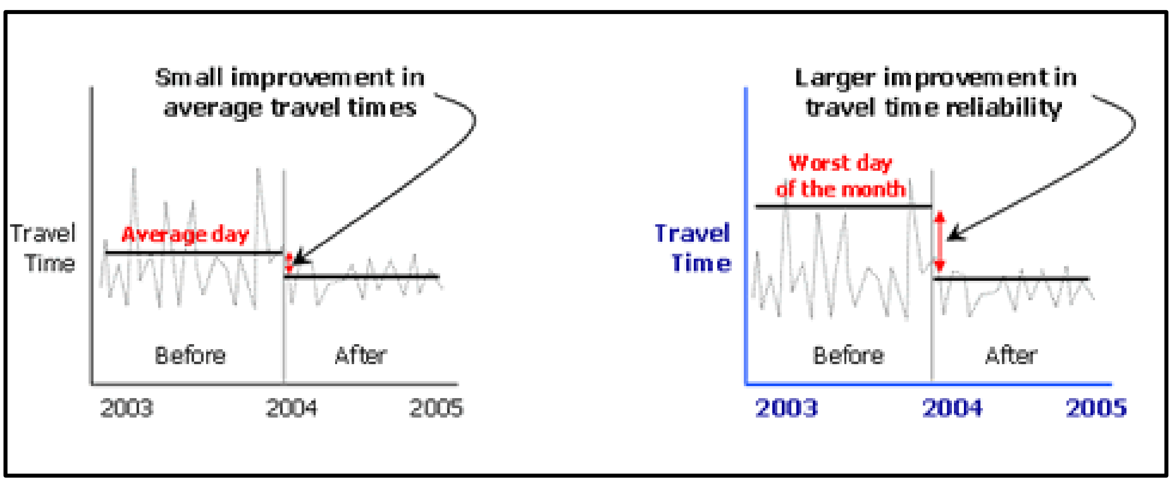


Figure 1-4:Reliability measures capture the benefits of traffic management

Since it more accurately measures the advantages of traffic management and operation operations than do simple averages, traffic experts understand the significance of trip time reliability. Take, for instance, a standard before-and-after research that aims to measure the advantages of a ramp metering or incident management program. The left side of Figure 1-4 illustrates how little the average journey time has improved. Reliability metrics, on the other hand, will show a far larger increase (right side of Figure 1-4) because they illustrate the impact of easing the worst few days of unanticipated delay.

1.4 Present Condition of Dhaka

Megacity Dhaka is the capital of Bangladesh having a population of approximately 21.7 million. With respect to an area of 306.4-kilometer square (worldpopulationreview.com, 2021). So, Dhaka is a densely populated city. In search of better life and improving financial condition, people especially who are poor tends to migrate to Dhaka in search of work from all around the country. So, the population of Dhaka is increasing day by day. In this population, majority of the people are middle class and poor. To these middle class and poor people, bus is a popular means of transport. Although bus is a popular means of transport in Dhaka but the service provided by public bus is Very poor. Moreover, the existing bus service is not adequate for passengers. So, people who can afford are getting attracted towards private vehicle. As a result, the number of private vehicles is increasing day by day. [5]

Traffic in Dhaka remains highly congested and problematic, significantly impacting daily life and the economy. On average, Dhaka residents lose around 3.2 million working hours every day due to traffic jams, costing the economy billions of dollars annually. This situation is exacerbated during rainy weather, which further slows down traffic and increases commuting times.

Abul Hasan Fazle Rabbi works in a business firm in Motijheel of the capital city Dhaka. He lives in Mirpur Section 10. He said, if he starts out by bus at 7:00 in the morning from Mirpur, it takes him around two and a half hours to reach office. And another two and a half hours back home.

According to Google Map, the distance from Mirpur Section 10 to Motijheel is around 12 km. Fazle Rabbi spends five hours every day commuting this distance to and from office, that too in a ramshackle bus. Speaking to Prothom Alo, he said, "When I joined this job in 2009, it took me just 40 to 50 minutes to come to office. Now it takes three times longer." [6]

Billal Hossain, an employee of a private company in Uttara, said " I left my office for New Market at 11am. It took three hours to reach destination. I do not know when I will come back. We spend many hours of our life on the road due to traffic jam." [7]

Figure 1-5:A Familiar Traffic in The Dhaka city (Mirpur 10)

Efforts to alleviate the congestion include initiatives by the Dhaka Metropolitan Police (DMP), such as optimizing bus stops, enforcing strict no-parking zones, and regulating the entry of heavy vehicles into the city. These measures aim to improve the flow of traffic and reduce gridlock.

Recent weather conditions, including rain, have intensified traffic issues, causing significant delays especially during peak hours. Commuters often face longer travel times and increased transportation costs under such conditions

Figure 1-6:Evening peak hour at Mirpur 14

Table 1-1: Number of registered motor vehicles in Dhaka (yearly)

Sl. No	Type of Vehicles	Upto-2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Grand Total
1	Ambulance	1277	137	114	188	253	355	284	399	456	548	599	614	5224
2	Auto Rickshaw	6571	112	110	59	56	428	582	42	5637	6839	114	112	20662
3	Auto Tempo	1405	1	0	0	0	0	0	0	0	0	0	0	1406
4	Bus	15018	1498	1217	968	1363	2219	3487	3294	2322	2951	1792	1213	37342
5	Cargo Van	3123	477	278	675	600	396	999	1286	1224	3	1	0	9062
6	Covered Van	4505	2033	1250	1916	2422	1940	2673	4068	4386	2529	1688	3350	32760
7	Delivery Van	11070	869	601	754	949	1531	1928	2207	1884	1292	967	1269	25321
8	Human Hauler	2097	568	145	115	109	502	786	217	211	0	2	0	4752
9	Jeep(Hard/Soft)	17839	1699	1242	1105	1582	3110	4217	4712	4863	5038	4450	6927	56784
10	Microbus	44015	3526	2630	2220	3833	4563	5162	4926	3583	3241	2407	4455	84561
11	Minibus	8293	135	103	83	136	103	155	158	185	186	133	186	9856
12	Motor Cycle	210879	34707	32808	26330	32891	46758	53718	75251	104051	99252	78551	99810	895006
13	Pick Up (Double/Single Cabin)	18688	7128	5069	4814	7185	7711	8370	10248	9598	8748	8024	8514	104097
14	Private Passenger Car	160170	11421	8179	9232	12972	18423	18013	19570	16318	15016	11150	14321	314785
15	Special Purpose Vehicle	525	59	28	78	50	66	224	233	500	410	144	123	2440
16	Tanker	737	151	85	133	162	143	203	187	323	235	177	157	2693
17	Taxicab	29551	52	43	3	301	53	30	3	94	6	0	0	30136
18	Tractor	7109	4168	2841	1634	1443	1637	2510	2754	3359	2503	2445	2556	34959
19	Truck	23836	4078	2740	3390	5704	4334	4306	7010	8725	6228	3327	4336	78014
20	Others	8793	786	666	651	961	1300	2559	3145	3593	3382	2283	2618	30737
	TOTAL	575501	73605	60149	54348	72972	95572	110206	139710	171312	158407	118254	150561	1780597

The majority of people in Dhaka City rely heavily on buses and minibuses for their daily transportation, although just 3.49% of all registered motor vehicles are these types of vehicles (see Table 1.1). Conversely, a minority of the population uses private vehicles—private passenger cars and jeeps, which account for 25.22% of all registered motor vehicles—for personal and commuting reasons. It is evident, therefore, that there are more private automobiles than there are buses and minibuses combined. Every day, there are more and more private automobiles on the road. [5] However, a megacity like Dhaka should not be pleased with the steadily rising number of private automobiles. Traffic congestion is occurring as a consequence of the space constraint. The only cars producing traffic jams are private ones, even in the absence of a major bus presence on the route

1.5 Objectives

The objectives of our thesis is understanding the variability of journey times helps to increase the accuracy of travel time projections and the dependability of traffic information services. Using the information gathered by the probe car, the study tries to investigate the variety of journey times in Dhaka. A thorough analysis of the distribution of trip times was carried out for different time frames. About every mean travel time level has a certain variability connected to it in terms of travel time variability. more travel times during the afternoon peak and morning off-peak have been shown to have lower coefficients of variation, although the morning peak's smaller mean travel time has more variability than other times of the day. [8]
objectives of the study can be stated as follows:

- To estimate the travel time reliability of the public transport
- To compare the travel time reliability of different roads.
- To estimate the buffer time and planning time.

1.6 Organization of The Thesis

The research work presented in this thesis paper is arranged into Six chapters.

- Chapter 1 covers Introduction
- Chapter 2 covers a literature review
- Chapter 3 includes Methodology
- Chapter 4 includes Data Collection
- Chapter 5 covers Analysis & Result
- Chapter 6 includes the conclusion.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

For millions of people globally, buses are their major form of transportation, making them an essential part of metropolitan transportation networks. The overall efficacy and appeal of bus services are significantly influenced by the consistency of bus journey times. r. According to Erdelić et al. (2021) and Tang et al. (2016), travel time is one of numerous measures used to measure the degree of congestion. [9]. The stability of bus travel times on a particular route, regardless of changing operational circumstances and other influences, is referred to as travel time dependability. In order to improve public transportation, draw in more passengers, and eventually support sustainable urban mobility, it is essential to comprehend and enhance bus trip time reliability.
Road transportation is causing more and more issues for urban areas. Globally, a large number of cities have put policies in place to support sustainable urban transportation. Pedestrians and bicycles enjoy a cleaner, calmer, and safer environment in metropolitan settings where automobile access and sharing are restricted. Given the societal significance of roads, these situations highlight the potential for a more effective and sustainable use of the urban road network as a "interactive and exchange space" as opposed to a mere "traffic space.". [9]

Numerous variables affect the dependability of bus journey time; they include operational and infrastructure concerns, traffic congestion, and weather. Bus travel time reliability becomes critical as cities develop and confront more obstacles in managing their transportation networks. Research on this topic has been focused on its complexity in recent years, with the goal of creating operational methods, measuring instruments, and tactics that would reduce variability and increase predictability.

Travel time reliability is a key performance indicator for traffic, and its significance in route choice analysis has increased. This study used the Buffer Time and Planning indices to assess the travel time reliability of the ten corridors that make up the Adelaide Metropolitan Road network. The results suggest that the Buffer Time indices for the selected corridors may vary greatly, with some showing values higher than 100%. Since the buffer time index seemed to overstate the evaluation of journey time reliability, further research into the trip time distribution was required. As this study shows, no one travel time distribution matches the normal distribution. For certain routes, however, the travel time distribution would line up with the log normal distribution.

This review of the literature explores the body of research on the reliability of bus travel times, looking at important topics like what constitutes a reliable bus, how to measure it, what influences reliability, how technology can be used to monitor and manage reliability, operational strategies for improvement, and the wider effects on passenger satisfaction and urban sustainability. This review seeks to offer a thorough grasp of the present state of knowledge in the subject by combining the results from various studies and highlighting any gaps that call for further research.

The significance of dependable bus transit cannot be emphasized, especially as urban populations rise and sustainable mobility gains prominence. In addition to providing advantages to passengers, a dependable and effective bus system also helps to create a more sustainable urban environment by lowering emissions, traffic congestion, and pollution. This literature study lays the groundwork for examining the complex issues and creative solutions that influence the bus travel time reliability landscape in modern metropolitan environments in light of these factors. It intends to educate policy and planning initiatives as well as future research activities with the goal of developing robust and efficient bus transportation networks via a synthesis of the body of current information.

2.2 Literature Review

Research on the reliability of transportation systems began in the 1980s and, in that time, much attention has been paid to the connectivity reliability, travel time reliability, and capacity reliability [10]. Among them, traveling time is one of the most significant travel features and is thought to be the primary element influencing individual activities and travel decision behavior, reliability of travel time is used to indicate the service quality of the transportation network from the perspective of travelers. [11]. There are two types of travel time reliability measurements: mathematical/theoretical and empirical/practical based, according to the literature currently in publication. [12]

Nowadays, traffic congestion is one of the main problems facing cities and, unfortunately, it is expected to deteriorate in the future [9]. Saberi and Bertini (2010) investigated the dependability of many connections within the study corridor using a few buffer time metrics, including the planning time index, transit time index, and buffer time index. Among the other metrics, they discovered that the buffer index and coefficient of variation had the highest consistency. [13]

2.3 Highway infrastructure and effects on public bus operations and travel time reliability

The major parameters considered in the literature on the effects of highway infrastructures on public bus operations and travel time include Total Bus-Stop Time (TBST), Bus Dwell Time (BDT), Boarding Time (BT), Alighting Time (AT), Travel Time (TT) along the road segment, Total Travel Time (TTT), Free Flow Speed (FFS). These measures were geared towards finding a reliable travel time determination tool.

2.4 Study Area

2.4.1 Study Area for Uttara

Latitude and longitude coordinates are: **23.873751, 90.396454**.

Uttara, often referred to as Uttara Model Town, is a sizable suburb situated north of Dhaka, the capital city of Bangladesh. The Bengali term "North" is the source of the suburb's name. With a total size of 36.91 km2 (14.25 sq mi), it was formed in 1966. Uttara and Hazrat Shahjalal International Airport are extremely near to each other. The area's train station is Dhaka Airport Railway Station. Based there is the famed Rajlokkhi Complex, a sizable retail center. The suburb has a few lakes and parks. [14]

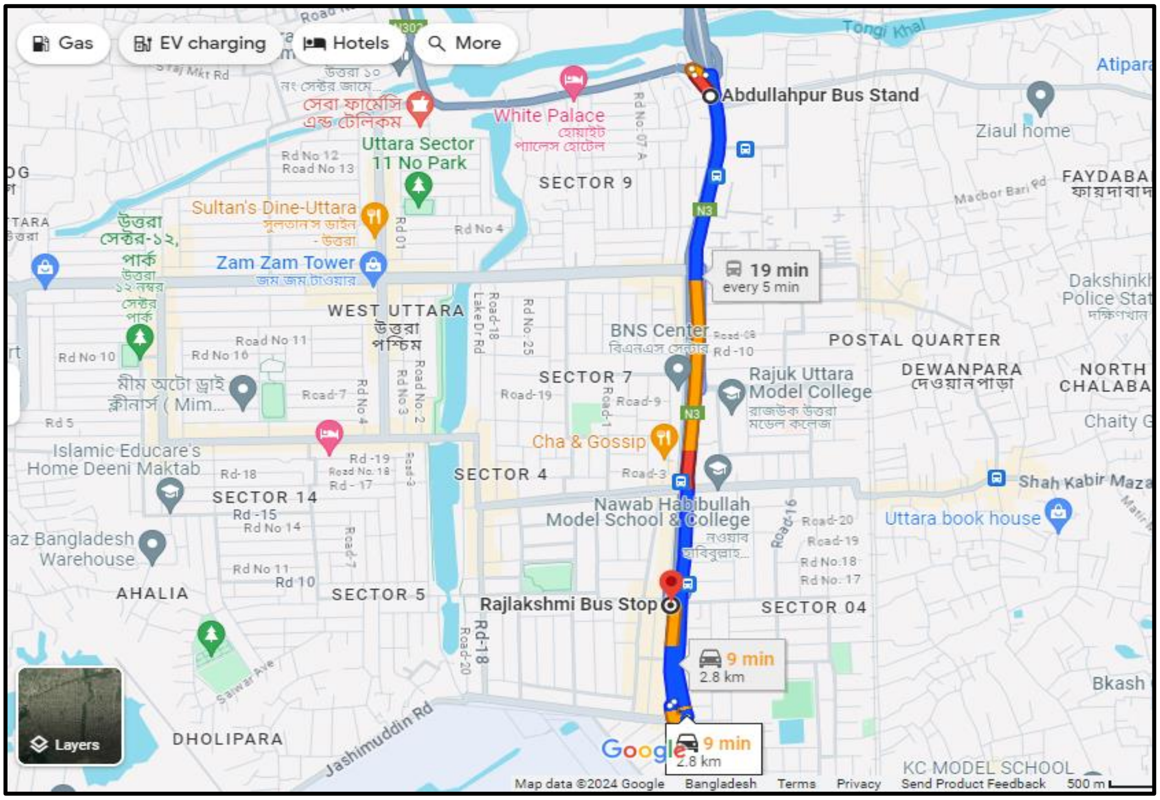


Figure 2-1:Abdullapur to Rajlaxmi

2.4.2 Study Area for Mirpur

Latitude and longitude coordinates are: **23.822350, 90.365417**.

Bangladesh's Mirpur is a northern neighborhood and bordering town of Dhaka. It is surrounded to the north by Pallabi and sits directly between the city's zoo and Hazrat Shahjalal International Airport in Dhaka. The overall population of the region is just over 100,000. The town was founded approximately 65 years ago, and about 30 years ago, it began to quickly expand as a capital city neighborhood. In Mirpur, there are a lot of tourist destinations and historical sites. The National Botanical Gardens of Bangladesh, an extensive stadium, cricket facilities, the historic structures of the nearby educational institutions, etc. are among them in addition to the zoo. [14]

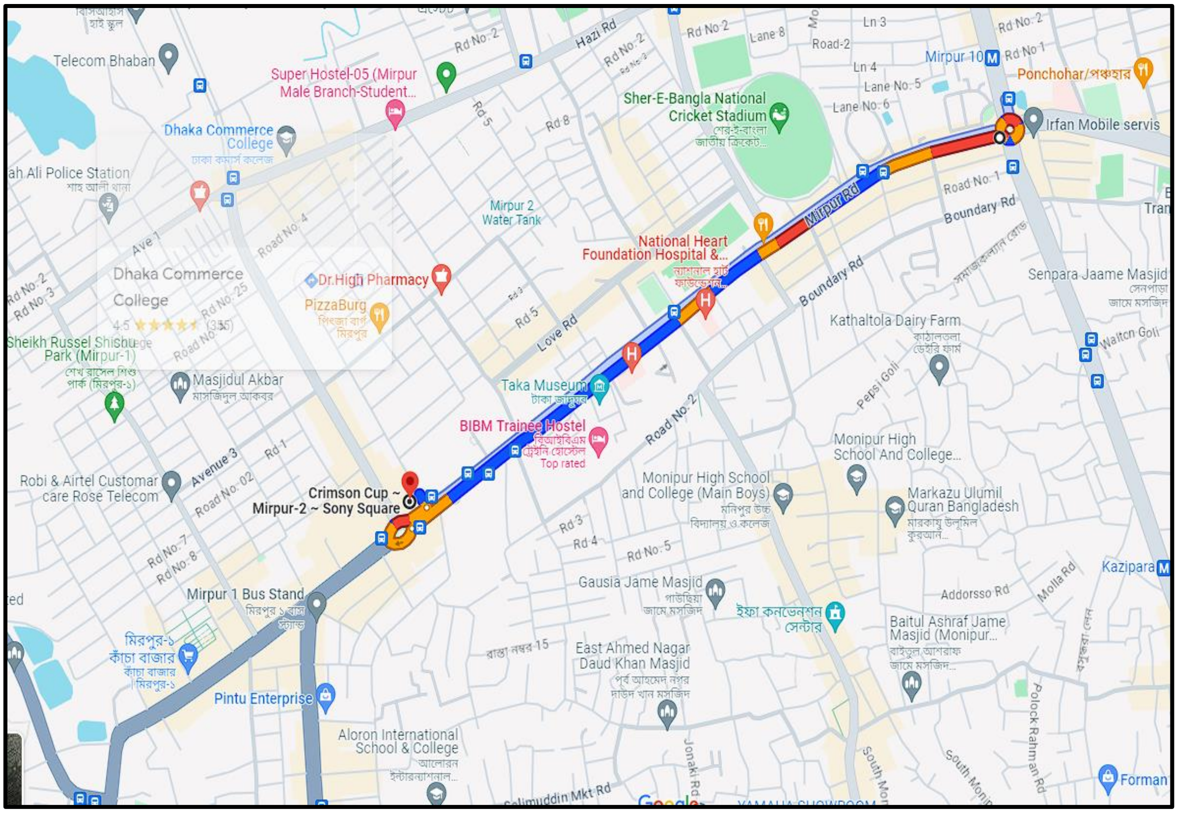


Figure 2-2: Mirpur 10 to Mirpur 2

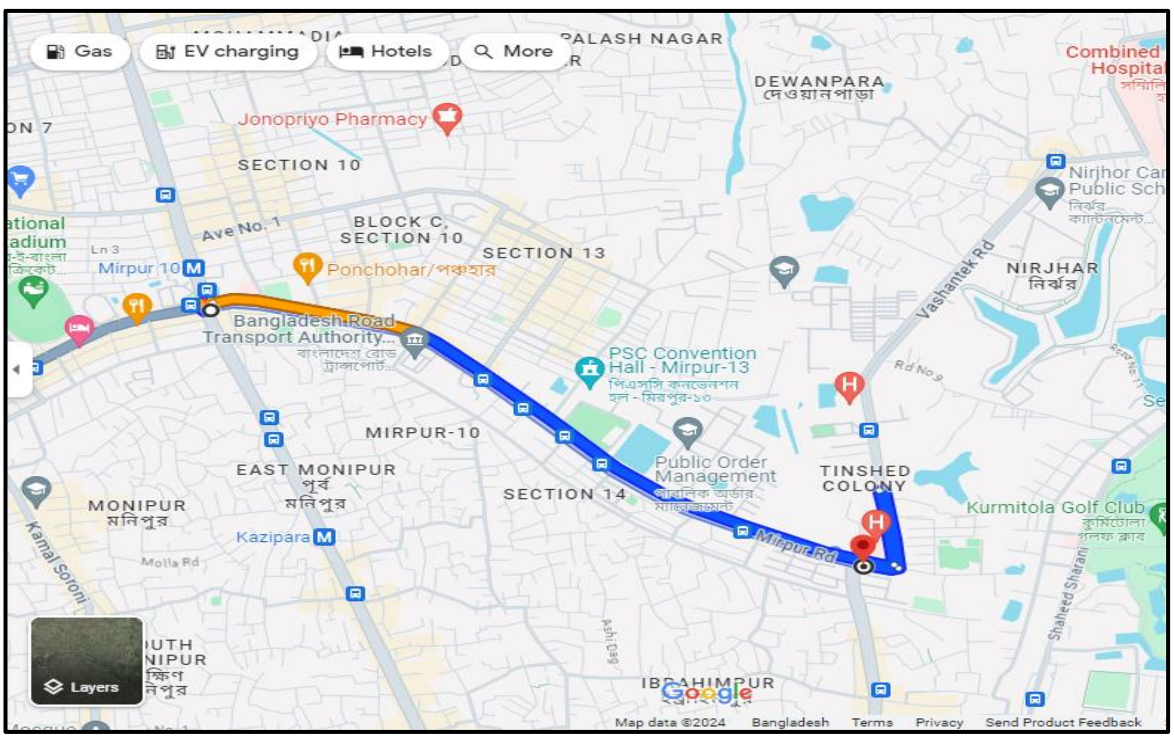


Figure 2-3: Mirpur 10 to Mirpur 14

CHAPTER III

METHODOLOGY

3.1 General

The basis for all of the reliability measures is route or point-to-point travel times. There are four basic ways in which these travel times can be developed:

1. Directly calculated from continuous probe vehicle data;
2. Estimated from continuous point-based detector data;
3. Collected in periodic special studies (e.g., floating car runs); and,
4. Estimated using computer simulation, sketch planning, or demand forecasting models. [15]

The reliability measure's intended application or uses, the breadth of the program, and the resources at hand will all play a major role in the choice of data gathering methods. To get journey time data, it's feasible to use more than one of these data gathering methods.
When directly comparing journey times from several ways, caution should be used since each approach may have distinct but consistent inherent biases.Consider, for instance, if travel times along a certain route have been gathered for three years via recurrent special studies. Using spot speeds, trip times may be estimated in the fourth year after deployment of point-based detectors. When comparing the journey time data from special studies for the first three years to the data from continuous point-based detectors for the fourth year, care should be used.

There aren't many organizations that use probing cars or other direct measuring methods to continually gather data on journey times. It is acknowledged that there will always be some mistake in the computation or estimation of journey time data. To ascertain if the expected estimate errors are more than those allowed for the applications of the reliability measures, one should use professional judgment. Agencies should also understand that improvements in traffic monitoring in the short and long run are probably going to provide more than enough high-quality and quantity trip time data for reliability assessments. [16]

3.2 Data Processing

It's possible that some intermediary data processing or reduction will be required once journey time data have been obtained. Most of the time, more thorough data collection methods will be used than those required to calculate dependability metrics. For instance, data from probe vehicles must be merged and linked to roads for certain amounts of time. Link-based trip time estimate for aggregate time periods will be necessary for point-based detector data. It will be necessary to extract travel time data from field gathering equipment and incorporate it into a database from specific studies. It will be necessary to incorporate travel time estimates from modeling procedures into a database. [16]

The measurement of travel time reliability is an emerging practice; however, a few measures appear to have technical merit and are easily understood by non-technical audiences. Most of these measures compare days with high delay to days with average delay. The four recommended measures: 90th or 95th percentile travel time, buffer index, planning time index, and frequency that congestion exceeds some expected threshold, are explained below.

3.2.1 The Planning Time Index

The Planning Time Index (PTI) is a critical indicator in the field of transportation planning and traffic engineering that has a significant impact on the careful assessment of travel time predictability and dependability. Precisely constructed, this invaluable and complicated measure becomes crucial in removing the temporal complexity that is present in travel planning. The PTI is essentially a carefully computed ratio that is the 95th percentile of travel time divided by the trip time in free flow. This precise computation allows for a more thorough understanding of the dynamic character of travel, including trip lengths that are higher than normal. The PTI, in short, goes beyond traditional measurements by providing planners and engineers with an advanced perspective that allows them to assess the resilience and robustness of transportation networks. Providing passengers with deep understanding of the temporal nuances of their travels is the PTI's main goal. The PTI becomes a vital tool in the toolbox of transportation experts by giving them a detailed insight of possible delays. More than just measuring, its goal is to assist passengers in the prudent distribution of extra time for their travels. The PTI acts as a lighthouse of predictability, allowing people to make wise choices about their travel arrangements in the face of unanticipated delays and changing traffic patterns. This measure is a defender of punctual arrivals because of its careful computations and strategic insights. It is more than just a figure of speech; it is a pledge to make sure people can accurately and confidently negotiate the complexities of transportation networks. Within the larger framework of transportation planning, the PTI stands out as a stable cornerstone, demonstrating the industry's commitment to improving the traveler experience. The PTI is a dynamic and adaptable tool that ensures that the trip is not merely a transit through place but also a carefully choreographed dance through time as cities expand and traffic dynamics change. The mathematical formulation of the PTI further refines its conceptual underpinnings:

$$\text{PTI} = \frac{\text{Planning Time}}{\text{Flow Travel Time}}$$

3.2.2 95th Percentile Travel Time

The 95th percentile travel time notion reveals itself as a deep investigation of the temporal nuances governing travel experiences. This aspect contains a color representation of the wide temporal range across which 95% of the recorded trip times smoothly unfurl, exposing the highest reaches of the enormous journey time tapestry. This measure is a compelling tool that provides not only a partial but also an all-encompassing view of the boundaries of temporal variability and unpredictable nature that are present in the complex dance of transportation systems. Exploring travel times in the 95th percentile reveals a world in which adventures transcend the commonplace and welcome the remarkable. It captures the instants in time when travel deviates from the expected and enters the expansive field of possible durations that constitute the boundaries of the temporal envelope. As a result, this aspect develops into a powerful story of the anomalies the moments when time deviates from the norm and tells the story of the longest and sometimes most unexpected travel experiences. Essentially, the 95th percentile journey time shows itself as an engrossing narrator of the temporal fabric, providing a detailed account of the longest possible travel times. It raises the conversation to reveal the spaces where the temporal journey takes unexpected twists, going beyond the traditional notion of averages and medians. This aspect is more than just a figure; it's a vivid representation of the diversity and energy woven into travel experiences. During the process of improving travel, transportation planners and traffic engineers encounter several challenges. One important aspect of this story is the 95th Percentile Travel Time. It acts as a compass to help interpret temporal anomalies and clear the path for calculated actions that would improve travel dependability and predictability. This aspect is a crescendo in the grand scheme of transportation planning, reflecting the varied and erratic rhythm of travel times and guaranteeing that both planners and travelers have a thorough awareness of the temporal range that transpires on the roads and thoroughfares of our ever-changing world.

3.2.3 Free-Flow Travel Time

The Free-Flow Travel Time is a conceptual cornerstone that represents the pinnacle of travel efficiency in an idealized, unrestricted environment within the complex field of transportation planning and traffic engineering. This aspect represents the theoretical journey time under ideal circumstances, free from the constraints of traffic or delays, and contrasts sharply with the difficulties of actual travel. It acts as a guiding standard, a lighthouse of what might be accomplished in the absence of outside obstacles.

$$\text{Free Flow Travel Time} = \frac{\text{Distance Travel}}{\text{Free Flow Speed}} \times 60$$

3.2.4 Buffer Index

The buffer index reflects the extra buffer time (or time cushions) that most passengers add to their average travel time when making travel plans to ensure on-time arrival. This additional time is included to allow for unforeseen delays. When dependability declines, the buffer index's value rises and is given as a percentage. For example, a buffer index of 30 percent means that, for a 15-minute average travel time, a traveler should budget an additional 4.5 minutes (15 minutes × 30 percent = 4.5 minutes) to ensure on-time arrival most of the time. In this example, the 8 extra minutes is called the buffer time. The buffer index is computed as the difference between the 95th percentile travel time and average travel time, divided by the average travel time.

A near-worst case time for a trip is represented by the 95th percentile travel time in this version of the buffer index. It is the additional time a traveler should budget for in order to be on time for 95% of all travels, whether it is stated as a percentage or in minutes. Using a 95 percent reliability indication as an example, a commuter or driver would only be late one weekday out of every month. [16]

$$\text{Buffer Index} = \frac{\text{95th percentile Travel Time(Minutes)} - \text{Average Travel Time(minutes)}}{\text{Average Travel Time (minutes)}} \times 100\%$$

3.2.5 Buffer Time

Buffer time measures the extra time that a traveler must add to the average travel time when planning for a trip

Buffer Time= Planning Time-Average Time

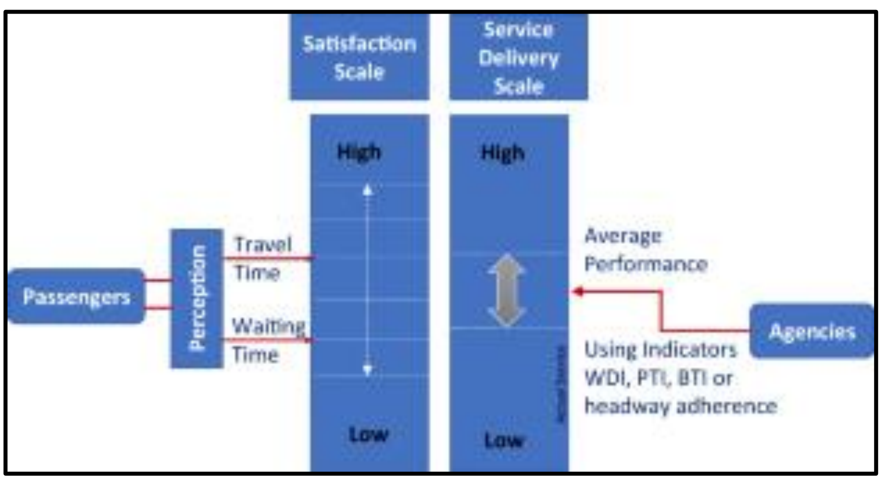


Figure 3-1:Public transport represents the viewpoints of passenger and agencies regarding travel time reliability

CHAPTER IV

DATA COLLECTION

4.1 Data Collecting Methods

During the period that we are collecting data, we observe the distance between the two station around 3km.One of our members collect the license plate, another member notes the starting time of the bus and another member waits other station to notes the departure time of that bus.

For the analysis, various crossings in Dhaka city were chosen by this way we collect the data for several station (Abdullapur to Rajlaxmi, Mirpur 2 to Mirpur 10 & Mirpur 10 to Mirpur 14). We collect the data 3 times- morning peak, off peak and evening peak. Each peak time we Collect 3 observations for each time. Total collected data sample 3 x 3 x 3 x3 = 81

Figure 4-1: Different data collection point

4.2 Primary Data Collection Method

The gathering of primary data might be carried out utilizing a wide number of distinct approaches. In spite of this, the research methods that are used the most commonly are interviews, field observations, self-administered questionnaires, and experiments. The gathering of primary data requires a greater investment of time and money in contrast to the acquisition of secondary data

The majority of the data that we used to construct this thesis came from surveys that we conducted and administered ourselves, as well as from field observations that we took. In order to collect the data we travel Abdullapur to Rajlaxmi,Mirpur 2 to Mirpur 10 and finally Mirpur 10 to Mirpur 14. Additionally, when we were gathering our data, we videotaped the majority of the thesis area using many cameras. In order for us to collect data in a manner that was both efficient and accurate.

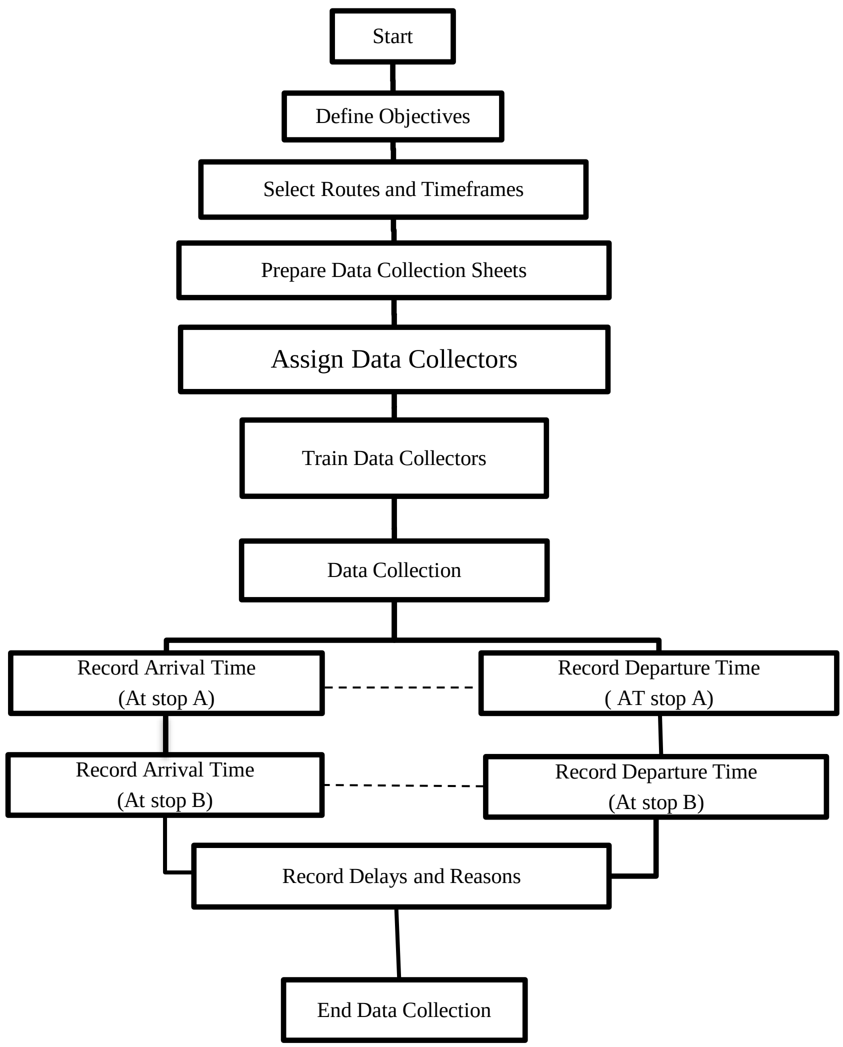


Figure 4-2:Data collection Flow Chart

4.3 Data Collection

Table 4-1: Bus Travel Time Count Rajlaxmi to Abdullapur

Day	Time (morning peak 9:00AM, off peak 12: 00PM and evening peak 5:	Upstream Bus stop name	Bus registration number/ bus number	Arrival time	Downstream Bus stop name	Departure time	Travel time (min) = Departure Time Arrival time	TT (min)	Distance travelled (km) = obtained from google map
Wednesday	Morning	Rajlaxmi	12-0623	9:44	Abdullahpur	9:30	14:00	14	2.9
			13-0610	9:43		9:31	12:00	12	2.9
			11-7247	9:45		9:33	12:00	12	2.9
	Off Peak	Rajlaxmi	15-3768	12:41	Abdullahpur	12:33	8:00	8	2.9
			11-7712	12:43		12:34	9:00	9	2.9
			11-4952	12:45		12:35	10:00	10	2.9
	Evening	Rajlaxmi	13-8541	17:38	Abdullahpur	17:19	19:00	19	2.9
			13-4912	17:36		17:20	16:00	16	2.9
			15-0984	17:41		17:22	19:00	19	2.9
Thursday	Morning	Rajlaxmi	14-6391	9:37	Abdullahpur	9:23	14:00	14	2.9
			13-0610	9:39		9:24	15:00	15	2.9
			11-7247	9:39		9:26	13:00	13	2.9
	Off Peak	Rajlaxmi	15-3768	12:52	Abdullahpur	12:43	9:00	9	2.9
			11-7712	12:54		12:44	10:00	10	2.9
			15-4578	12:51		12:44	7:00	7	2.9
	Evening	Rajlaxmi	15-2796	17:29	Abdullahpur	17:12	17:00	17	2.9
			13-0785	17:31		17:13	18:00	18	2.9
			11-1147	17:33		17:15	18:00	18	2.9
Friday	Morning	Rajlaxmi	12-0623	10:13	Abdullahpur	10:07	6:00	6	2.9
			13-0610	10:15		10:09	6:00	6	2.9
			11-7247	10:18		10:10	8:00	8	2.9
	Off Peak	Rajlaxmi	15-3768	12:22	Abdullahpur	12:17	5:00	5	2.9
			11-7712	12:24		12:18	6:00	6	2.9
			12-9988	12:25		12:18	7:00	7	2.9
	Evening	Rajlaxmi	15-1954	17:25	Abdullahpur	17:12	13:00	13	2.9
			15-5731	17:27		17:13	14:00	14	2.9
			11-1973	17:29		17:13	16:00	16	2.9

Table 4-2: Bus Travel Time Count Mirpur 2 to Mirpur 10

Day	Time (morning peak 9:00AM, off peak 12: 00PM and evening peak 5:	Upstream Bus stop name	Bus registration number/ bus number	Arrival time	Downstream Bus stop name	Departure time	Travel time (min) = Departure timeArrival time	TT (min)	Distance travelled (km) = obtained from google map
Thursday	Morning	Mirpur-2 (Sony)	11-3213	9:13	Mirpur 10	9:00	13:00	13	1.7
			13-3261	9:16		9:02	14:00	14	1.7
			13-2132	9:17		9:05	12:00	12	1.7
	Off Peak	Mirpur-2 (Sony)	11-3241	12:19	Mirpur 10	12:10	9:00	9	1.7
			15-2871	12:20		12:11	9:00	9	1.7
			11-3279	12:22		12:14	8:00	8	1.7
	Evening	Mirpur-2 (Sony)	15-1287	17:20	Mirpur 10	17:05	15:00	15	1.7
			12-7611	17:25		17:08	17:00	17	1.7
			15-0921	17:27		17:10	17:00	17	1.7
Friday	Morning	Mirpur-2 (Sony)	12-4981	9:18	Mirpur 10	9:10	8:00	8	1.7
			12-2325	9:18		9:11	7:00	7	1.7
			11-2564	9:22		9:14	8:00	8	1.7
	Off Peak	Mirpur-2 (Sony)	15-0911	12:08	Mirpur 10	12:03	5:00	5	1.7
			13-2187	12:11		12:05	6:00	6	1.7
			11-7192	12:14		12:09	5:00	5	1.7
	Evening	Mirpur-2 (Sony)	11-1082	17:28	Mirpur 10	17:10	18:00	18	1.7
			15-2193	17:29		17:12	17:00	17	1.7
			12-9210	17:32		17:15	17:00	17	1.7
Saturday	Morning	Mirpur-2 (Sony)	11-3821	9:16	Mirpur 10	9:02	14:00	14	1.7
			11-3280	9:18		9:04	14:00	14	1.7
			13-3921	9:22		9:07	15:00	15	1.7
	Off Peak	Mirpur-2 (Sony)	15-0182	12:16	Mirpur 10	12:04	12:00	12	1.7
			15-8101	12:17		12:06	11:00	11	1.7
			11-3281	12:20		12:09	11:00	11	1.7
	Evening	Mirpur-2 (Sony)	12-8181	17:16	Mirpur 10	17:01	15:00	15	1.7
			15-4311	17:21		17:05	16:00	16	1.7
			11-3800	17:23		17:08	15:00	15	1.7

Table 4-3: Bus Travel Time Count Mirpur 14 to Mirpur 10

Day	Time (morning peak 9:00AM, off peak 12: 00PM and evening peak 5:	Upstream Bus stop name	Bus registration number/ bus number	Arrival time	Downstream Bus stop name	Departure time	Travel time (min) = Departure timeArrival time	TT (min)	Distance travelled (km) = obtained from google map
Wednesday	Morning	Mirpur-14	15-7111	9:13	Mirpur-10	9:00	13:00	13	2.3
			11-2139	9:14		9:02	12:00	12	2.3
			11-1283	9:18		9:06	12:00	12	2.3
	Off Peak	Mirpur-14	12-2189	12:09	Mirpur-10	12:01	8:00	8	2.3
			15-9113	12:13		12:04	9:00	9	2.3
			15-3287	12:12		12:05	7:00	7	2.3
	Evening	Mirpur-14	11-3298	17:26	Mirpur-10	17:15	11:00	11	2.3
			12-3890	17:30		17:17	13:00	13	2.3
			12-2980	17:32		17:20	12:00	12	2.3
Thursday	Morning	Mirpur-14	15-1871	9:13	Mirpur-10	9:02	11:00	11	2.3
			11-2390	9:16		9:05	11:00	11	2.3
			15-2337	9:22		9:10	12:00	12	2.3
	Off Peak	Mirpur-14	12-3244	12:12	Mirpur-10	12:05	7:00	7	2.3
			11-5010	12:17		12:08	9:00	9	2.3
			12-0981	12:18		12:10	8:00	8	2.3
	Evening	Mirpur-14	11-1515	17:11	Mirpur-10	17:00	11:00	11	2.3
			15-2171	17:13		17:03	10:00	10	2.3
			13-1398	17:16		17:05	11:00	11	2.3
Friday	Morning	Mirpur-14	15-6570	9:08	Mirpur-10	9:02	6:00	6	2.3
			11-5478	9:10		9:04	6:00	6	2.3
			13-1728	9:18		9:11	7:00	7	2.3
	Off Peak	Mirpur-14	15-8347	12:10	Mirpur-10	12:03	7:00	7	2.3
			11-2371	12:11		12:05	6:00	6	2.3
			13-2387	12:16		12:10	6:00	6	2.3
	Evening	Mirpur-14	13-3413	17:10	Mirpur-10	17:01	9:00	9	2.3
			11-3498	17:12		17:04	8:00	8	2.3
			15-3980	17:16		17:07	9:00	9	2.3

CHAPTER V

DATA ANALYSIS & RESULT

5.1 General

As a result, a thesis statement for a research paper address a how determining issue.

5.2 Analysis Basis

Variation in the current data.

5.3 Analysis Procedure

STEP 1. Determine how measures will be used

- Define the structure of bus travel time reliability
- Monitor conditions of roadway.

STEP 2. Develop a plan based on uses and users

- Define travel modes, routes, trips, days, times of interest
- Define data source and calculation procedures
- Develop communication tools for results

STEP 3. Collect and process required data

- Continuous data collection
- Use quality assurance methods
- Calculate route or trip travel times (basic data element)

STEP 4. Calculate reliability measures

- 95th or other percentile travel time
- Buffer index
- Planning time index

5.4 Variation in Current Data

In this part, we show the variation at Abdillapur to Rajlaxmi, Mirpur 2 to Mirpur10, Mirpur 10 to Mirpur 14. In variation in data analysis. Several roads are selected in Dhaka city for the analysis. After analysis all there are huge different in travel time reliability.

5.5 Sample Data Calculation

- Free Flow Travel Time= $\frac{\text{distance Travel}}{\text{Free Flow Speed}} \times 60$

$= \frac{2.9}{40} \times 60$

= 4.35 min

- Average travel time=$\frac{\text{Total Tavel Time}}{\text{Number of times}}$

=$\frac{14+12+12}{3}$

$= 12.67$

- Buffer Time=Planning Time-Average Time

=13.8-12.67

=1.13 min

- Buffer Index $= \frac{\text{95th percentile Travel Time} - \text{Average Travel Time}}{\text{Average Travel Time}} \times 100\%$

$= \frac{13.8 - 12.67}{12.67} \times 100\%$

=8.95%

- Planning Time Index= $\frac{\text{Planning Time}}{\text{Flow Travel Time}}$

=$\frac{13.8}{4.35}$

$= 3.17$

Table 5-1: Data Analysis Abdullapur to Rajlaxmi

Day	Time (morning peak 9:00AM, off peak 12: 00PM and evening peak 5: 00PM)	Travel time (min) from survey form	Distance travelled (in km) from survey form	Free flow speed = 40km/hr for urban road as per RHD, equivalent to 666.67 m/min	Free flow travel time (min) = Distance travelled/ free flow speed	Planning time = 95th percentile travel time =PERCENTILE.INC(E29:E31, 0.95)	Average travel time	Buffer time = (95th percentile travel time - Average travel time)	Buffer index = (95th percentile travel time-average travel time)/average travel time	Planning time index = Planning time/free flow travel time
Wednesday	Morning	14	2.9	40	4.35	13.8	12.67	1.13	8.95%	3.17
		12	2.9	40	4.35					
		12	2.9	40	4.35					
	Off Peak	8	2.9	40	4.35	9.9	9	0.9	10.00%	2.28
		9	2.9	40	4.35					
		10	2.9	40	4.35					
	Evening	19	2.9	40	4.35	19	18	1	5.56%	4.37
		16	2.9	40	4.35					
		19	2.9	40	4.35					
Thursday	Morning	14	2.9	40	4.35	14.9	14	0.9	6.43%	3.43
		15	2.9	40	4.35					
		13	2.9	40	4.35					
	Off Peak	9	2.9	40	4.35	9.9	8.67	1.23	14.23%	2.28
		10	2.9	40	4.35					
		7	2.9	40	4.35					
	Evening	17	2.9	40	4.35	18	17.67	0.33	1.89%	4.14
		18	2.9	40	4.35					
		18	2.9	40	4.35					
Friday	Morning	6	2.9	40	4.35	7.8	6.67	1.13	17.00%	1.79
		6	2.9	40	4.35					
		8	2.9	40	4.35					
	Off Peak	5	2.9	40	4.35	6.9	6	0.9	15.00%	1.59
		6	2.9	40	4.35					
		7	2.9	40	4.35					
	Evening	13	2.9	40	4.35	15.8	14.33	1.47	10.23%	3.63
		14	2.9	40	4.35					
		16	2.9	40	4.35					

Table 5-2: Data Analysis Mirpur 2 to Mirpur 10

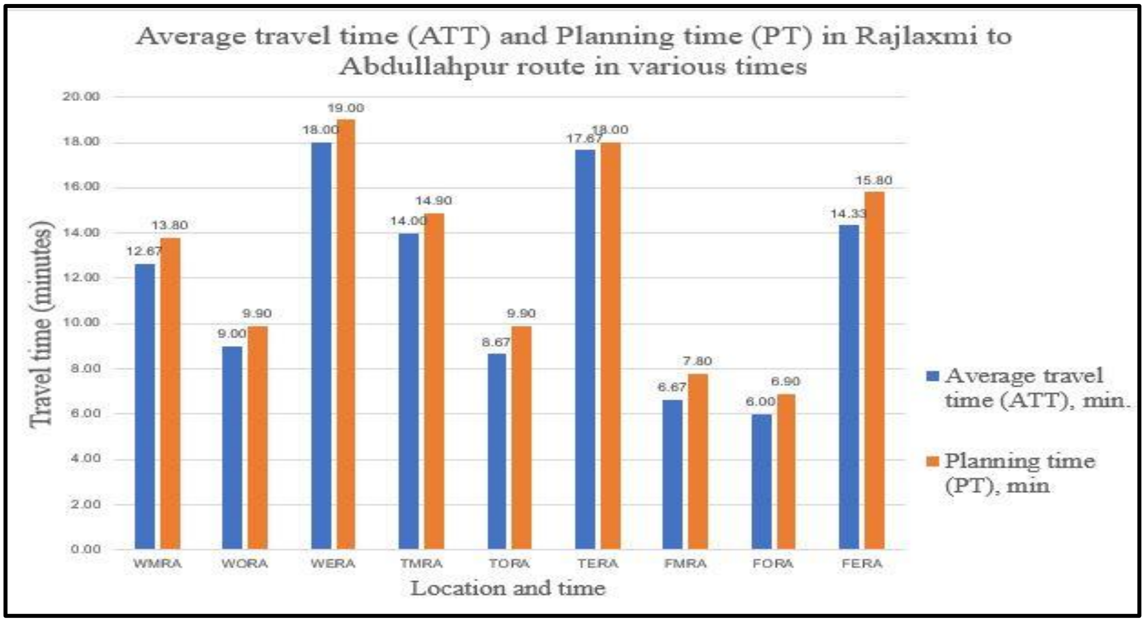
Day	Time (morning peak 9:00AM, off peak 12: 00PM and evening peak 5: 00PM)	Travel time (min) from survey form	Distance travelled (in km) from survey form	Free flow speed = 40km/hr for urban road as per RHD, equivalent to 666.67 m/min	Free flow travel time (min) = Distance travelled/free flow speed	Planning time = 95th percentile travel time =PERCENTILE.INC(E29:E31, 0.95)	Average travel time	Buffer time = (95th percentile travel time - average travel time)	Buffer index = (95th percentile travel time- average travel time)/average travel time	Planning time index = Planning time/free flow travel time
Thursday	Morning	13	1.7	40	2.55	13.9	13	0.9	6.92%	5.45
		14	1.7	40	2.55					
		12	1.7	40	2.55					
	Off Peak	9	1.7	40	2.55	9	8.67	0.33	3.85%	3.53
		9	1.7	40	2.55					
		8	1.7	40	2.55					
	Evening	15	1.7	40	2.55	17	16.33	0.67	4.08%	6.67
		17	1.7	40	2.55					
		17	1.7	40	2.55					
Friday	Morning	8	1.7	40	2.55	8	7.67	0.33	4.35%	3.14
		7	1.7	40	2.55					
		8	1.7	40	2.55					
	Off Peak	5	1.7	40	2.55	5.9	5.33	0.57	10.63%	2.31
		6	1.7	40	2.55					
		5	1.7	40	2.55					
	Evening	18	1.7	40	2.55	17.9	17.33	0.57	3.27%	7.02
		17	1.7	40	2.55					
		17	1.7	40	2.55					
Saturday	Morning	14	1.7	40	2.55	14.9	14.33	0.57	3.95%	5.84
		14	1.7	40	2.55					
		15	1.7	40	2.55					
	Off Peak	12	1.7	40	2.55	11.9	11.33	0.57	5.00%	4.67
		11	1.7	40	2.55					
		11	1.7	40	2.55					
	Evening	15	1.7	40	2.55	15.9	15.33	0.57	3.70%	6.24
		16	1.7	40	2.55					
		15	1.7	40	2.55					

Table 5-3: Data Analysis Mirpur 10 to Mirpur 14

Day	Time (morning peak 9:00AM, off peak 12:00PM and evening peak 5:00PM)	Travel time (min) from survey form	Distance travelled (in km) from survey form	Free flow speed = 40km/hr for urban road as per RHD, equivalent to 666.67 m/min	Free flow travel time (min) = Distance travelled/ free flow speed	Planning time = 95th percentile travel time =PERCENTILE.INC (E29:E31, 0.95)	Average travel time	Buffer time = (95th percentile travel time - average travel time)	Buffer index = (95th percentile travel time- average travel time)/average travel time	Planning time index = Planning time/free flow travel time
Wednesday	Morning	13	2.3	40	3.45	12.9	12.33	0.57	4.59%	3.74
		12	2.3	40	3.45					
		12	2.3	40	3.45					
	Off Peak	8	2.3	40	3.45	8.9	8	0.9	11.25%	2.58
		9	2.3	40	3.45					
		7	2.3	40	3.45					
	Evening	11	2.3	40	3.45	12.9	12	0.9	7.50%	3.74
		13	2.3	40	3.45					
		12	2.3	40	3.45					
Thursday	Morning	11	2.3	40	3.45	11.9	11.33	0.57	5.00%	3.45
		11	2.3	40	3.45					
		12	2.3	40	3.45					
	Off Peak	7	2.3	40	3.45	8.9	8	0.9	11.25%	2.58
		9	2.3	40	3.45					
		8	2.3	40	3.45					
	Evening	11	2.3	40	3.45	11	10.67	0.33	3.13%	3.19
		10	2.3	40	3.45					
		11	2.3	40	3.45					
Friday	Morning	6	2.3	40	3.45	6.9	6.33	0.57	8.95%	2
		6	2.3	40	3.45					
		7	2.3	40	3.45					
	Off Peak	7	2.3	40	3.45	6.9	6.33	0.57	8.95%	2
		6	2.3	40	3.45					
		6	2.3	40	3.45					
	Evening	9	2.3	40	3.45	9	8.67	0.33	3.85%	2.61
		8	2.3	40	3.45					
		9	2.3	40	3.45					

Table 5-4: Summary of Data analysis

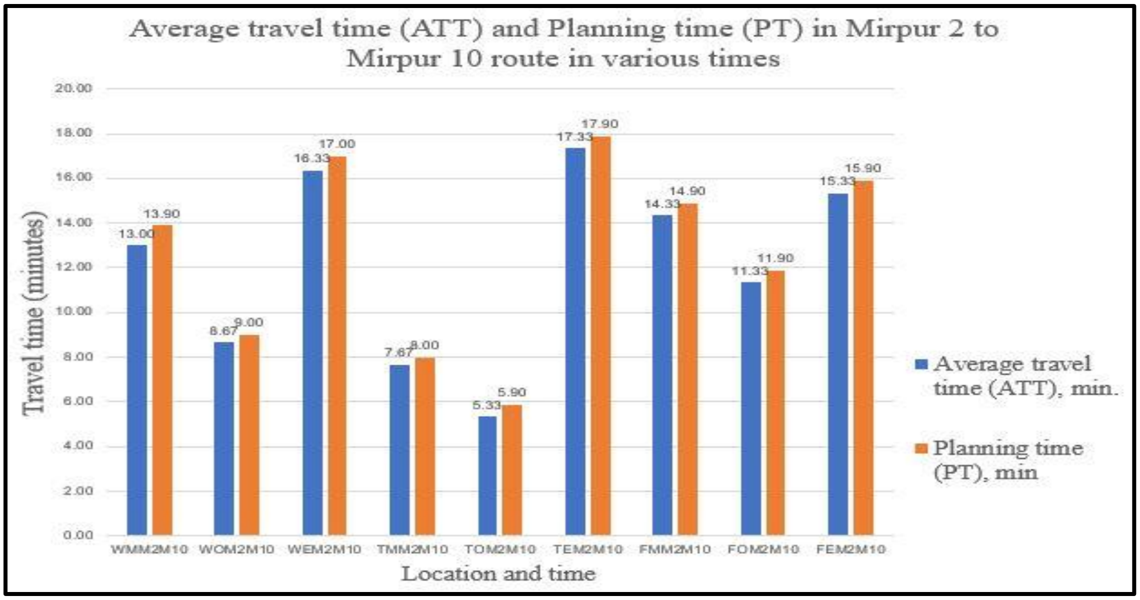
Abbreviation	Location and time	Planning time (PT), min	Average travel time (ATT), min.	Buffer time (BT), min	Buffer index (BI)	Planning time index (PTI)
WMRA	Wednesday morning Rajlaxmi to Abdullahpur	13.80	12.67	1.13	8.95%	3.17
WORA	Wednesday offpeak Rajlaxmi to Abdullahpur	9.90	9.00	0.90	10.00%	2.28
WERA	Wednesday evening Rajlaxmi to Abdullahpur	19.00	18.00	1.00	5.56%	4.37
TMRA	Thursday morning Rajlaxmi to Abdhullahpur	14.90	14.00	0.90	6.43%	3.43
TORA	Thursday offpeak Rajlaxmi to Abdhullahpur	9.90	8.67	1.23	14.23%	2.28
TERA	Thursday evening Rajlaxmi to Abdhullahpur	18.00	17.67	0.33	1.89%	4.14
FMRA	Friday morning Rajlaxmi to Abdhullahpur	7.80	6.67	1.13	17.00%	1.79
FOR A	Friday offpeak Rajlaxmi to Abdhullahpur	6.90	6.00	0.90	15.00%	1.59
FERA	Friday evening Rajlaxmi to Abdhullahpur	15.80	14.33	1.47	10.23%	3.63
WMM2M10	Wednesday morning Mirpur 2 to Mirpur 10	13.90	13.00	0.90	6.92%	5.45
WOM2M10	Wednesday offpeak Mirpur 2 to Mirpur 10	9.00	8.67	0.33	3.85%	3.53
WEM2M10	Wednesday evening Mirpur 2 to Mirpur 10	17.00	16.33	0.67	4.08%	6.67
TMM2M10	Thursday morning Mirpur 2 to Mirpur 10	8.00	7.67	0.33	4.35%	3.14
TOM2M10	Thursday offpeak Mirpur 2 to Mirpur 10	5.90	5.33	0.57	10.63%	2.31
TEM2M10	Thursday evening Mirpur 2 to Mirpur 10	17.90	17.33	0.57	3.27%	7.02
FMM2M10	Friday morning Mirpur 2 to Mirpur 10	14.90	14.33	0.57	3.95%	5.84
FOM2M10	Friday offpeak Mirpur 2 to Mirpur 10	11.90	11.33	0.57	5.00%	4.67
FEM2M10	Friday evening Mirpur 2 to Mirpur 10	15.90	15.33	0.57	3.70%	6.24
WMM14M10	Wednesday morning Mirpur 14 to Mirpur 10	12.90	12.33	0.57	4.59%	3.74
WOM14M10	Wednesday offpeak Mirpur 14 to Mirpur 10	8.90	8.00	0.90	11.25%	2.58
WEM14M10	Wednesday evening Mirpur 14 to Mirpur 10	12.90	12.00	0.90	7.50%	3.74
TMM14M10	Thursday morning Mirpur 14 to Mirpur 10	11.90	11.33	0.57	5.00%	3.45
TOM14M10	Thursday offpeak Mirpur 14 to Mirpur 10	8.90	8.00	0.90	11.25%	2.58
TEM14M10	Thursday evening Mirpur 14 to Mirpur 10	11.00	10.67	0.33	3.13%	3.19
FMM14M10	Friday morning Mirpur 14 to Mirpur 10	6.90	6.33	0.57	8.95%	2.00
FOM14M10	Friday off-peak Mirpur 14 to Mirpur 10	6.90	6.33	0.57	8.95%	2.00
FEM14M10	Friday evening Mirpur 14 to Mirpur 10	9.00	8.67	0.33	3.85%	2.61



The graph depicts the Average Travel Time (ATT) and Planning Time (PT) for the Rajlaxmi to Abdullahpur route at different times on Wednesday, Thursday, and Friday.

During Wednesday morning rush hours, the actual travel time (12.67 minutes) is slightly less than the planned time (13.80 minutes), indicating some traffic congestion but a relatively manageable commute. During off-time, both ATT (9.00 minutes) and PT (9.90 minutes) are lower, suggesting a quicker and more efficient journey with less traffic. The Wednesday evening commute has a higher ATT (18.00 minutes) compared to PT (19.00 minutes), indicating potential traffic congestion and a longer-than-planned travel time.On Thursday morning, actual travel time (14.00 minutes) is slightly less than the planned time (14.90 minutes), suggesting some congestion but a manageable commute. Off-peak hours again show lower ATT and PT, emphasizing a smoother journey without significant delays. Thursday evening commute has a slightly higher ATT (17.67 minutes) than PT (18.00 minutes), indicating some congestion but overall adherence to the planned time.Friday morning sees a notably lower ATT (6.67 minutes) compared to PT (7.80 minutes), indicating a quicker and more efficient commute during the morning hours. Similar to Friday morning, off-peak hours result in a quick and predictable journey. The Friday evening commute shows a slightly less ATT (14.33 minutes) than PT (15.80 minutes), suggesting some traffic congestion, but overall the travel time remains close to the planned time.

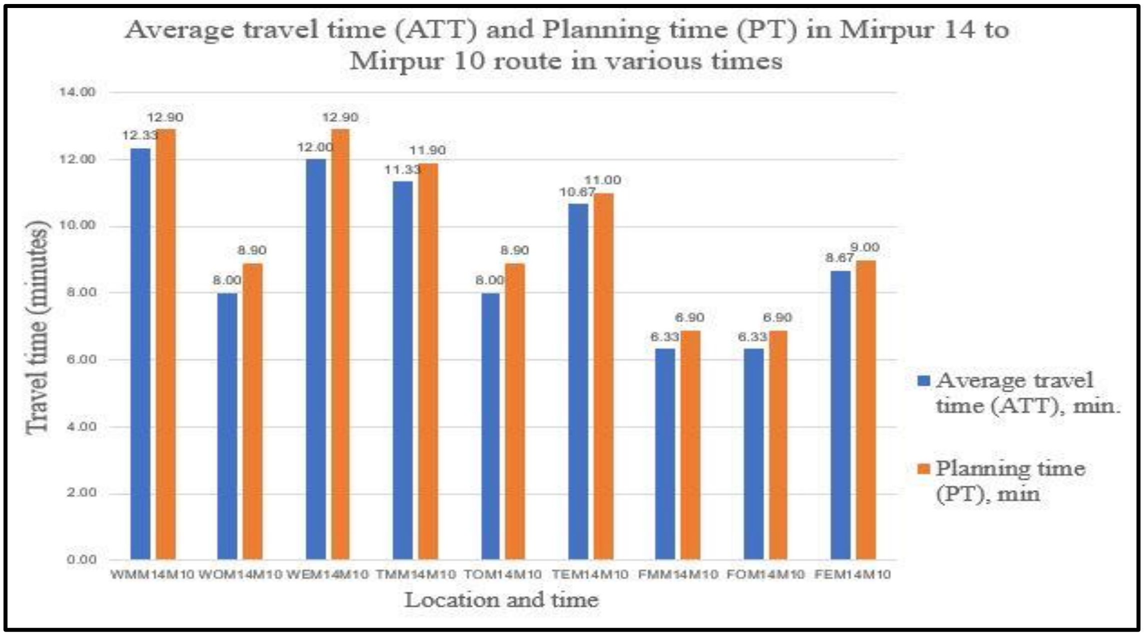
The graph illustrates variations in travel time, with morning office hours potentially causing congestion, while off-peak hours generally result in more efficient commutes. The evening commutes show mixed patterns, with some days experiencing congestion and others maintaining adherence to planned times.



The graph represents the average travel time (ATT) and planning time (PT) for the Mirpur 2 to Mirpur 10 route at different times on Wednesday, Thursday, and Friday.

The average travel time during office hours is 13.00 minutes, with a slightly higher planning time of 13.90 minutes, possibly due to traffic jams or delays. Off-peak hours see a decrease in travel time and planning time to 8.67 and 9.00 minutes, indicating smoother traffic conditions.The average travel time during evening hours is 16.33 minutes, with a planning time of 17.00 minutes, indicating potential traffic congestion. On Thursdays, the average travel time is 7.67 minutes during office hours and 8.00 minutes during off-time, suggesting a smoother commute. However, on Thursday evenings, the average travel time increases to 17.33 minutes and planning time to 17.90 minutes, indicating potential traffic delays. These findings suggest potential congestion during evening hours.The average travel time on Friday mornings is 14.33 minutes, with a planning time of 14.90 minutes, indicating traffic congestion. Off-peak hours have smoother conditions, with travel and planning times decreasing to 11.33 and 11.90 minutes, respectively. In the evening, travel time increases to 15.33 minutes, indicating potential traffic challenges.

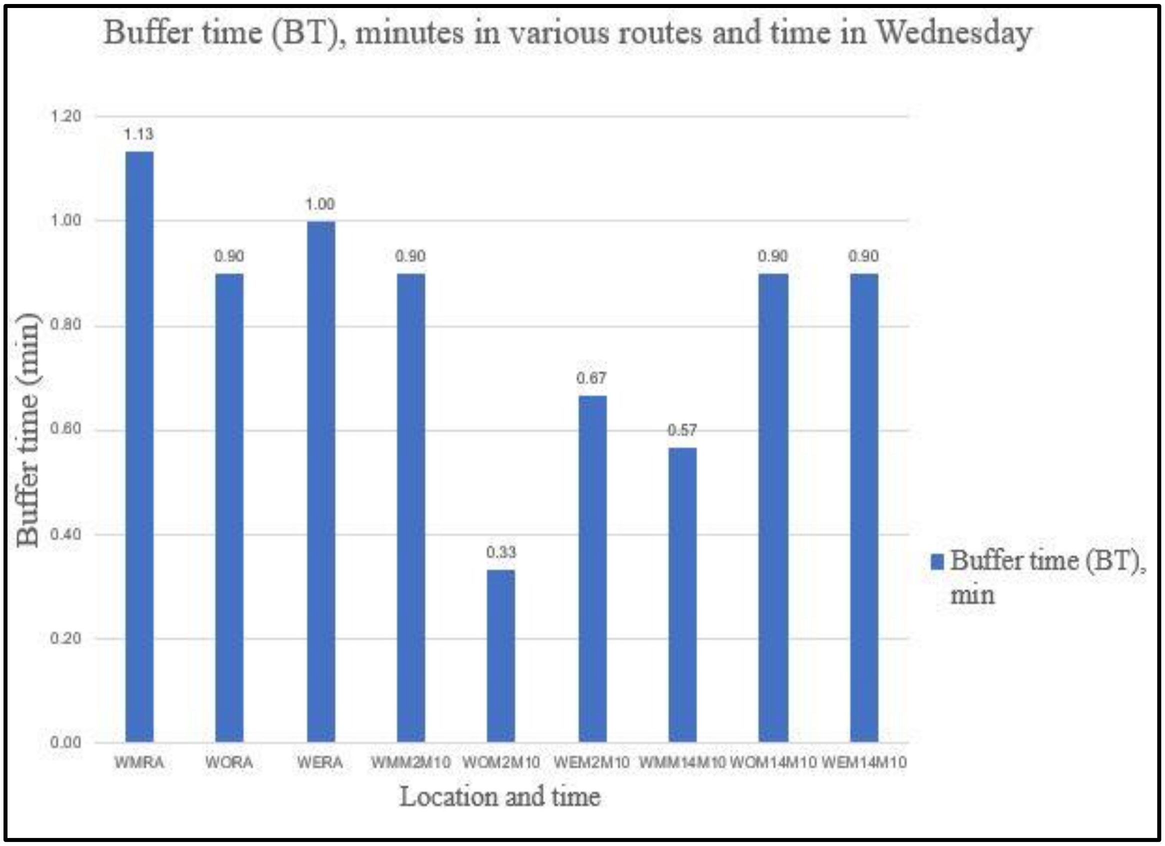
In summary, the graph highlights variations in travel times during different times of the day and on different days of the week. The average travel time generally tends to be lower than the planning time, emphasizing the impact of traffic conditions on the overall commute experience.



The graph represents the Average Travel Time (ATT) and Planning Time (PT) for the route from Mirpur 14 to Mirpur 10 at different times on Wednesday, Thursday, and Friday.

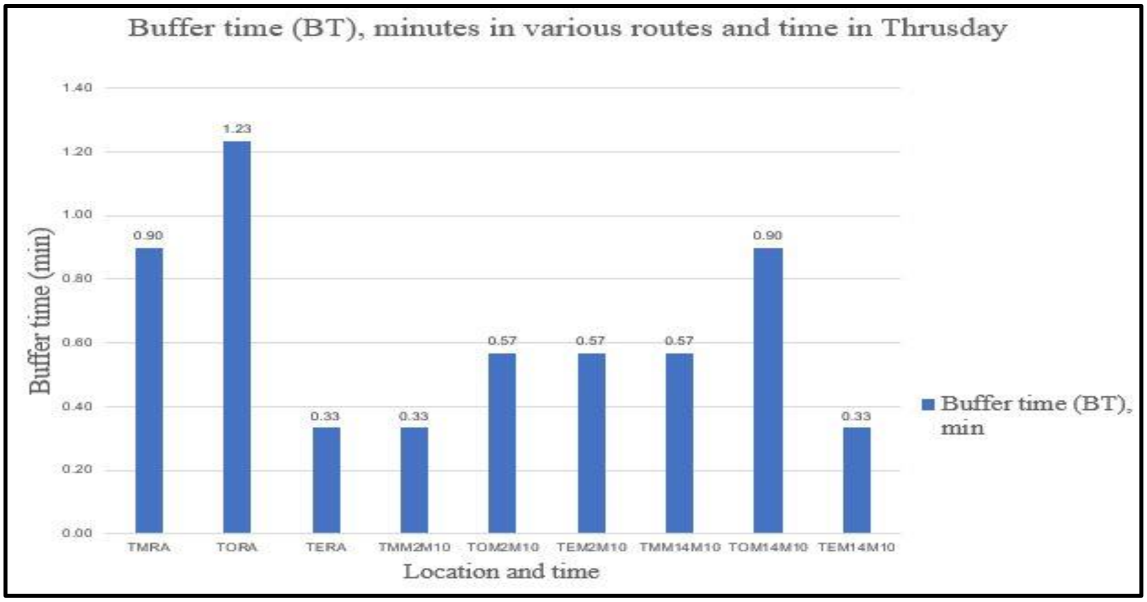
The actual travel time is slightly shorter than the planned time, indicating a smooth commute despite traffic congestion. Off-peak hours show lower ATT (8.00 minutes) and PT (8.90 minutes), indicating a quicker and more efficient journey. The evening commute has similar ATT (12.00 minutes) and PT (12.90 minutes), possibly due to consistent traffic conditions. On Thursday, the actual travel time is slightly less than the planned time, indicating a manageable commute. Off-time shows lower ATT (8.00 minutes) and PT (8.90 minutes), indicating a smoother journey without significant delays.The evening commute on Thursday has a slightly higher ATT (10.67 minutes) than PT (11.00 minutes), indicating some traffic congestion but overall adherence to the planned time. Friday morning sees a notably lower ATT (6.33 minutes) compared to PT (6.90 minutes), indicating a quicker and more efficient commute. In the Friday morning, off-peak time, result in a quick and predictable journey. The Friday evening commute shows a slightly higher ATT (8.67 minutes) than PT (9.00 minutes), indicating some traffic congestion, but overall the travel time remains close to the planned time.

In summary, the data suggests that during morning office hours, traffic congestion may cause the actual travel time to be slightly less than the planned time.However, during off-time, the commute tends to be more efficient with lower both ATT and PT. The evening commutes vary, with some days showing close alignment between ATT and PT and others indicating potential traffic delays



For the analysis Buffer time (BT), min in Wednesday morning Rajlaxmi to Abdullahpur Planning time (PT), 13.80 min and Average travel time (ATT), 12.67 min. Buffer time (BT) is, 1.13min. Wednesday off-peak Rajlaxmi to Abdullahpur Planning time (PT), 9.90 min and Average travel time (ATT), 9.00 min. Buffer time (BT) is, 0.90min. Wednesday evening Rajlaxmi to Abdullahpur Planning time (PT), 19.00 min and Average travel time (ATT), 18.00 min. Buffer time (BT) is, 1.00min. Wednesday morning Mirpur 2 to Mirpur 10 Planning time (PT), 13.90 min and Average travel time (ATT), 13.00 min. Buffer time (BT) is, 0.90min. Wednesday off-peak Mirpur 2 to Mirpur 10 Planning time (PT), 9.00 min and Average travel time (ATT), 8.67 min. Buffer time (BT) is, 0.33min. Wednesday evening Mirpur 2 to Mirpur 10

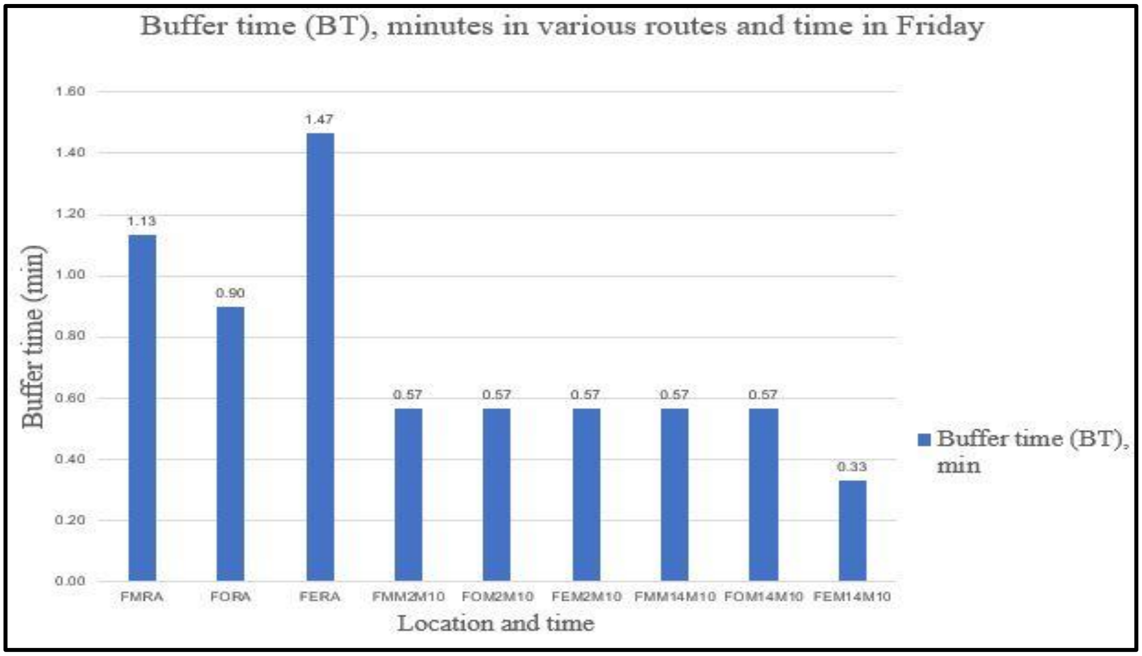
Planning time (PT), 17.00 min and Average travel time (ATT), 16.33 min. Buffer time (BT) is, 0.67min. Wednesday morning Mirpur 14 to Mirpur 10 Planning time (PT), 12.90 min and Average travel time (ATT), 12.33 min. Buffer time (BT) is, 0.57min. Wednesday off-peak Mirpur 14 to Mirpur 10 Planning time (PT), 8.90 min and Average travel time (ATT), 8.00 min. Buffer time (BT) is, 0.90 min. Wednesday evening Mirpur 14 to Mirpur 10 Planning time (PT), 12.90 min and Average travel time (ATT), 12.00 min. Buffer time (BT) is, 0.90 min.



The graph represents Buffer Time (BT) for a bus on different routes and at different times on Thursday. Buffer Time refers to the time the bus spends at various bus stops, allowing passengers to board and alight.

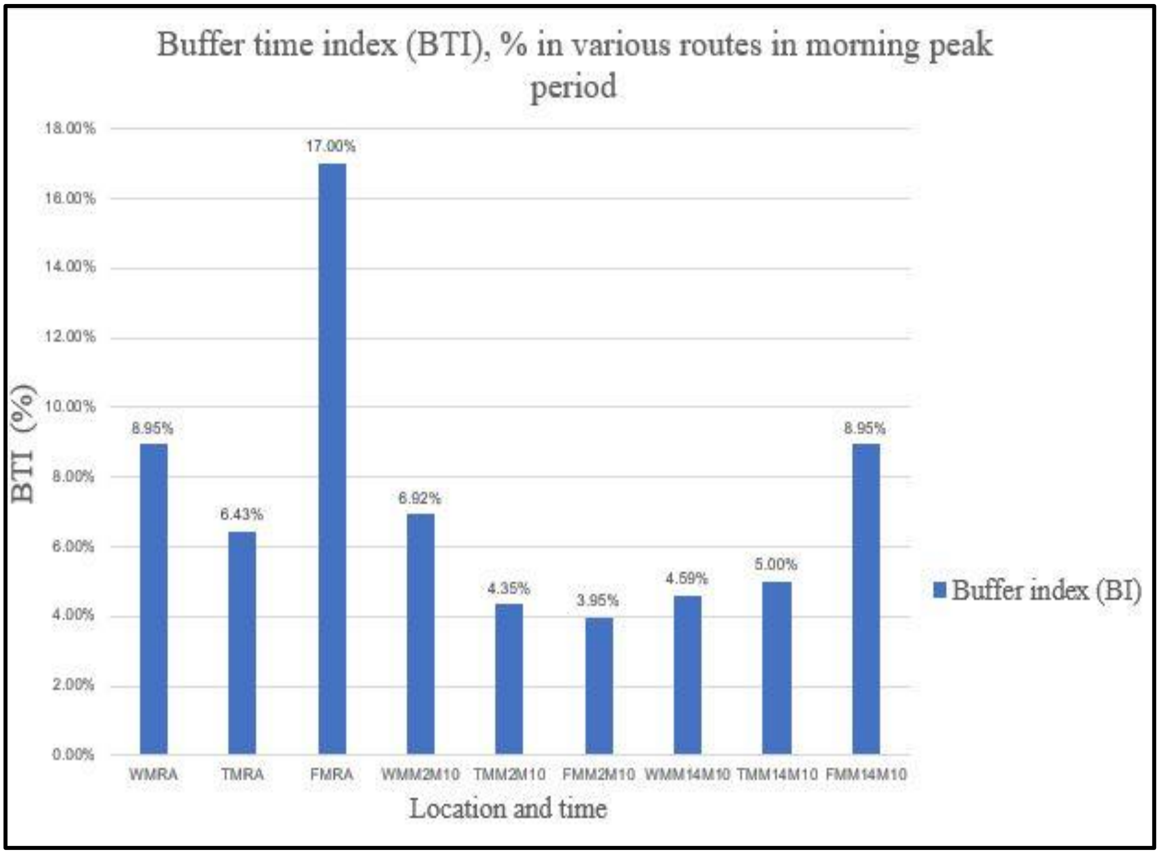
In the morning, the bus spends 0.90 minutes of time at bus stops for passenger boarding and alighting. During off-time, the buffer time increases to 1.23 minutes, indicating a longer stoppage at bus stops. In the evening, the buffer time decreases to 0.33 minutes, indicating a shorter stoppage at bus stops.When traveling from Mirpur 2 to Mirpur 10 in the morning, the buffer time is 0.33 minutes, indicating a relatively short stoppage at bus stops. During off-time on the Mirpur 2 to Mirpur 10 route, the buffer time increases to 0.57 minutes, suggesting a slightly longer stoppage. In the evening on the Mirpur 2 to Mirpur 10 route, the buffer time remains at 0.57 minutes, indicating a consistent stoppage duration.When traveling from Mirpur 14 to Mirpur 10 in the morning, the buffer time is 0.57 minutes, suggesting a moderate stoppage duration. During off-peak time on the Mirpur 14 to Mirpur 10 route, the buffer time increases to 0.90 minutes, indicating a longer stoppage. In the evening on the Mirpur 14 to Mirpur 10 route, the buffer time decreases to 0.33 minutes, suggesting a shorter stoppage.

In summary, the graph illustrates variations in buffer time (BT) for the bus at different times and on different routes on Thursday. The morning and evening times, as well as the routes, influence the duration of stoppages for passenger boarding and alighting.



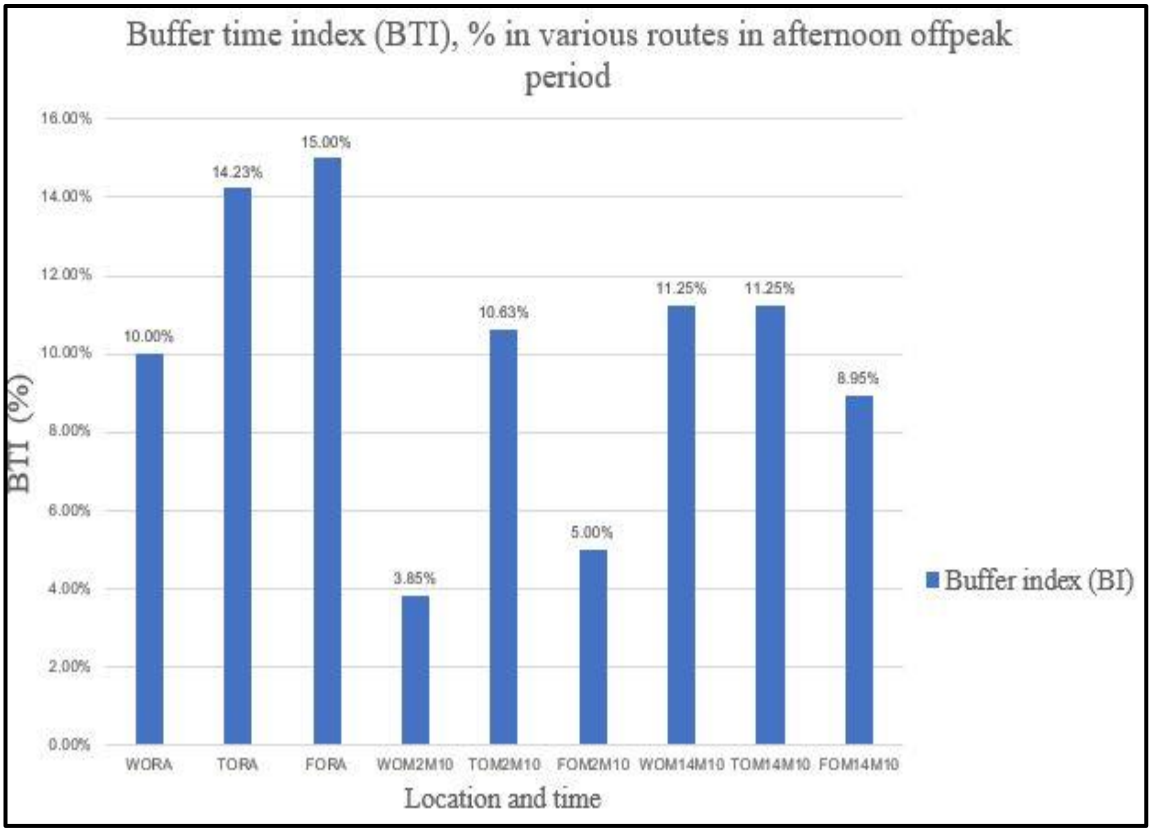
This chart provide the information about the buffer time of Uttara and Mirpur.In the chart we can observe that between the two area(Uttara & Mirpur) have huge different for the Buffer Time. 1.47min buffer time In the evening period at Uttara .It is the highest among the all columns & the lowest buffer time at Mirpur 14 to Mirpur 10.it’s about 0.33 min.In the graph we can notice that at Mirpur there is no huge different among the column. All the column’s buffer time 0.57 min.

So,we can easily observe that according to the condition of those city it makes huge different in buffer time.At Uttara there are so many school,college,office,home,shopping mall etc.Which covers a large portion of this area. Many people gather in this place for their daily purpose.As a result it causes a lot of traffic jam. Traffic jams exert a notable influence on buffer time, the extra temporal cushion individuals or organizations incorporate into their schedules to counteract unforeseen delays. As congestion on roads slows down the pace of travel, individuals often find it necessary to allot additional buffer time to accommodate the unpredictability associated with prolonged commutes. The impact extends beyond mere travel time, affecting punctuality for appointments and meetings. Traffic jams cause uncertainty, requiring businesses to incorporate buffer time into logistics planning to manage disruptions and ensure a smooth supply chain. This strategic approach helps mitigate stress and enhance productivity, while also addressing economic ramifications like increased fuel consumption and transportation costs. Buffer time contributes to schedule resilience and operational efficiency, making it a pragmatic solution to managing traffic congestion.



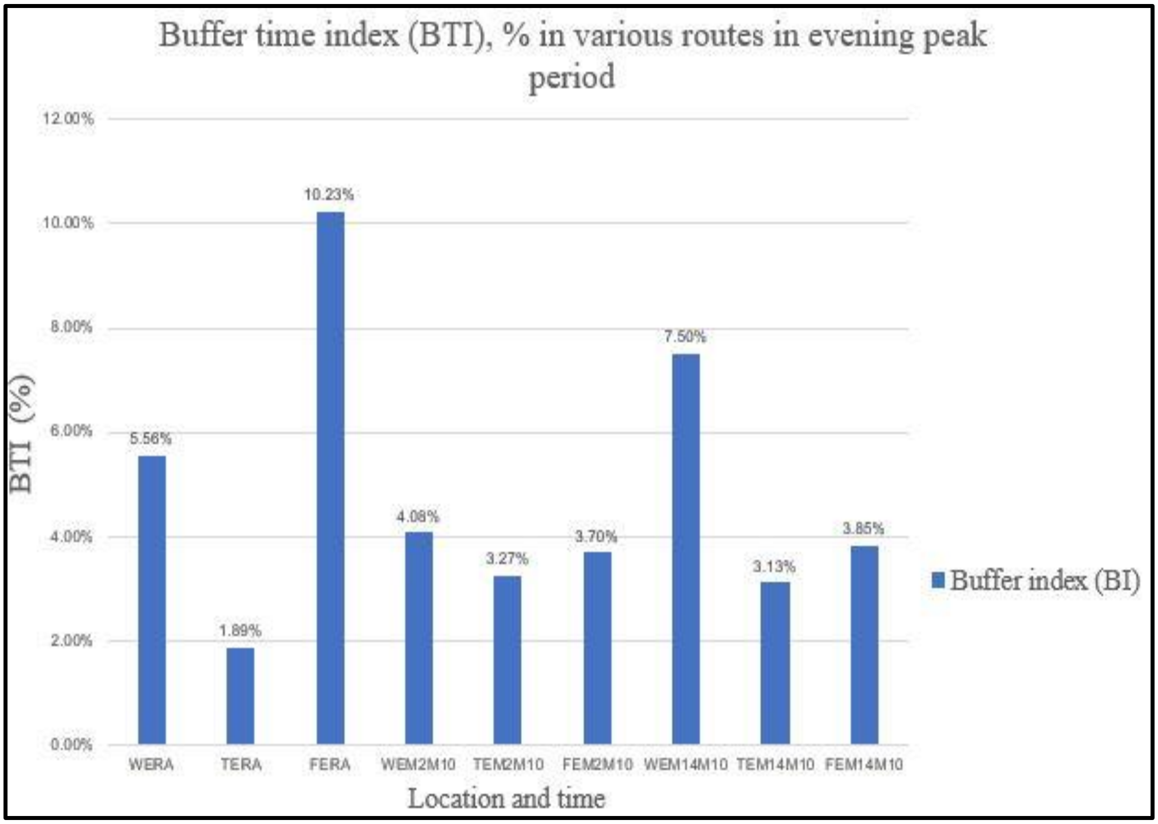
This chart provides the information about the buffer time index in morning peak period at Uttara and Mirpur.In the graph we can observe that the highest buffer index at FMRA. This column covers 17% of buffer Time Index. In the chart we can see that same data in WMRA & FMM14M10. Two columns hold same percentage buffer time index.The percent for both column 8.95%..On the other hand FMM2M10 is the lowest percentage among the all columns. The percentage for this column 3.95%. others column contain buffer index around 4% to 7%

So we can tell that at Uttara there is a huge buffer time compare to the Mirpur area.



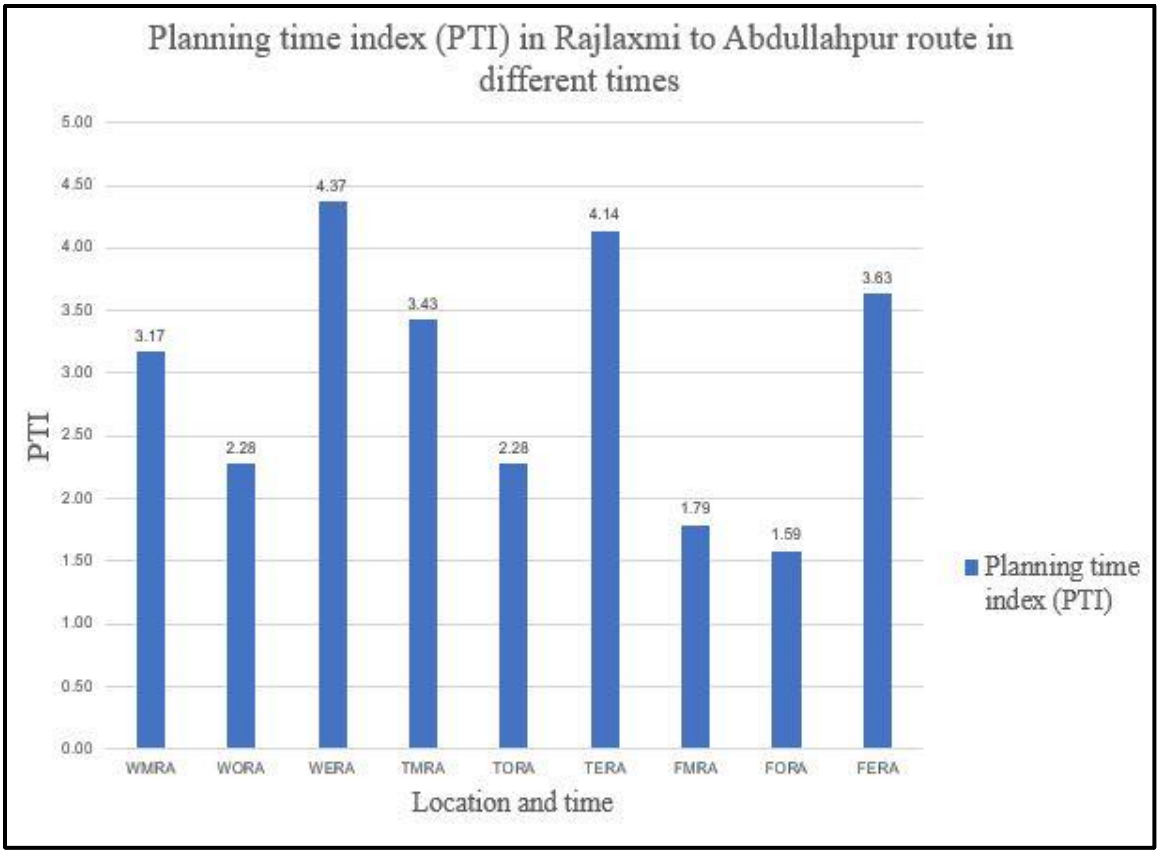
This chart provides the information about the buffer index time in afternoon offpeak period.Here we can see that in the afternoon period all the column little bit higher to the morning period.

The highest percentange on Friday at abdullapur to rajlaxmi.its about 15%.At the second position we can observe on Thursday.its almost 14.23%.but on Wednesday much lower about 10%.At Mirpur we can see that all the columns around 11%.Surprisely when we see the column WOM2M10 it’s the lowest data about 3.85%.

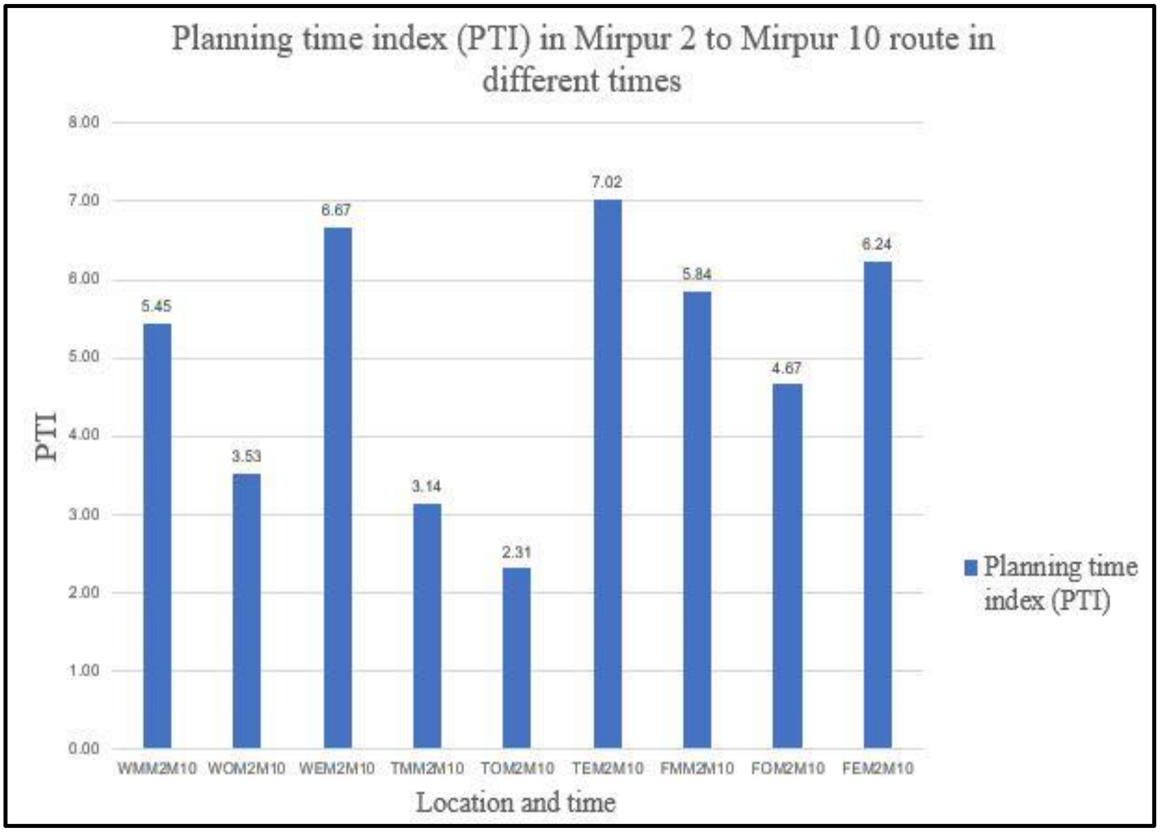


This chart provides the information about buffer time index in evening period in various routes.In the chart we observe that its almost close to the morning period data.In the chart we can see that the highest percent buffer time index in FERA. It's about 10.23%.then we can observe two data which is 7.5% & 5.56% .These are gradually WEM14M10 &WERA.If we compare to the others zone we can see that in those zone buffer time index little bit low.Those area's percentage around 3%.Finally we can see that the lowest percentage at TERA.About 1.89% in that area.

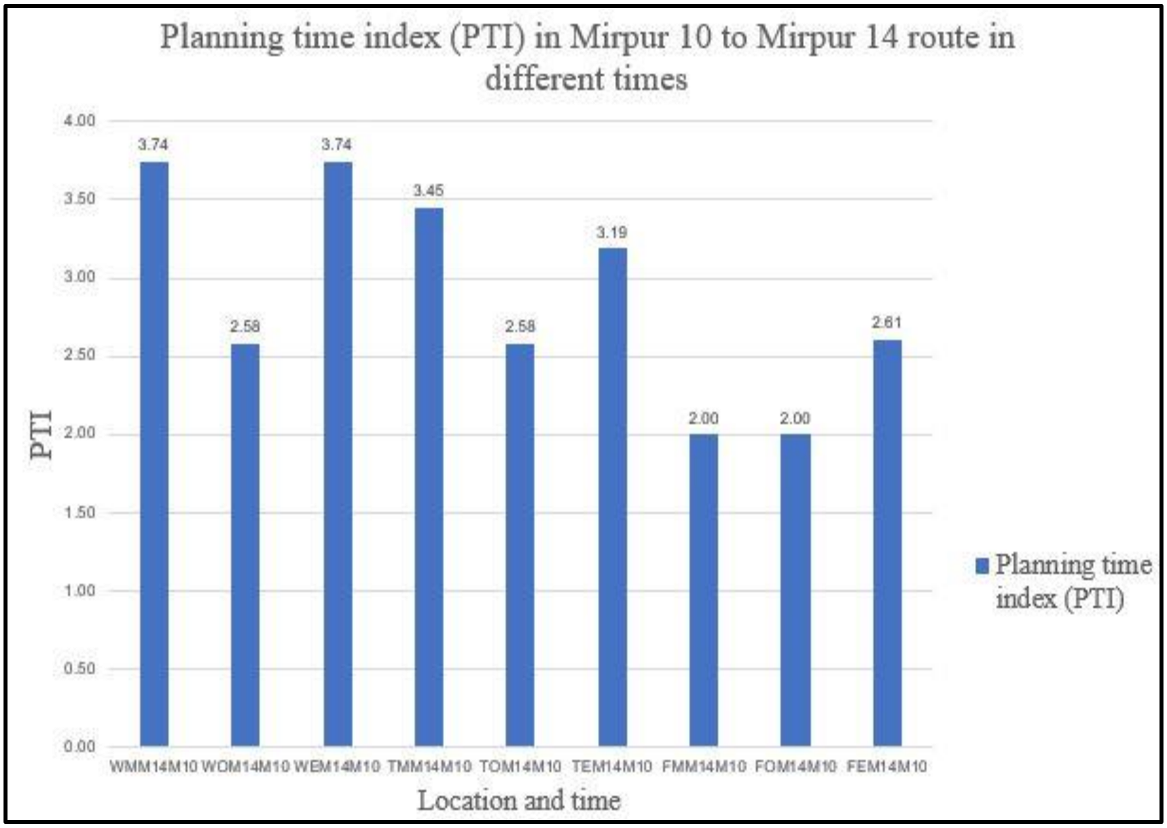
So we can tell that, The surge in traffic during Friday evenings in Uttara, Dhaka, can be attributed to a confluence of factors. As the workweek concludes, individuals are eager to kick off their weekend, prompting increased movement for social and recreational activities. The appeal of shopping centers, entertainment venues, and popular eateries draws people out, contributing to concentrated traffic in these areas. Additionally, Friday evenings often hold significance for religious practices or congregational prayers, prompting community members to gather, further intensifying local traffic. The culmination of work commutes, social gatherings, and the general exodus from daily routines amplifies congestion on the roadways. In the absence of robust public transportation options, reliance on private vehicles becomes more pronounced, exacerbating the overall traffic scenario. The intricate interplay of these factors underscores the Friday evening phenomenon of heightened traffic in Uttara, Dhaka.



For the analysis, Rajlaxmi to Abdullahpur were chosen. First Wednesday morning Rajlaxmi to Abdullahpur Planning time (PT), 13.80 min and Free flow travel time 4.35 min Planning time index (PTI) is 3.17. Wednesday off-peak Rajlaxmi to Abdullahpur Planning time (PT), 9.9 min and Free flow travel time 4.35 min Planning time index (PTI) is 2.28. Wednesday evening Rajlaxmi to Abdullahpur Planning time (PT), 19 min and Free flow travel time 4.35 min Planning time index (PTI) is 4.37. Thursday morning Rajlaxmi to Abdhullahpur Planning time (PT), 14.9 min and Free flow travel time 4.35 min Planning time index (PTI) is 3.43. Thursday off-peak Rajlaxmi to Abdhullahpur Planning time (PT), 9.9 min and Free flow travel time 4.35 min Planning time index (PTI) is 2.28. Thursday evening Rajlaxmi to Abdhullahpur Planning time (PT), 18 min and Free flow travel time 4.35 min Planning time index (PTI) is 4.14. Friday morning Rajlaxmi to Abdhullahpur Planning time (PT), 7.8 min and Free flow travel time 4.35 min Planning time index (PTI) is 1.79. Friday off-peak Rajlaxmi to Abdhullahpur Planning time (PT), 6.9 min and Free flow travel time 4.35 min Planning time index (PTI) is 1.59. Friday evening Rajlaxmi to Abdhullahpur Planning time (PT), 15.8 min and Free flow travel time 4.35 min Planning time index (PTI) is 3.63. In Wednesday evening Rajlaxmi to Abdullahpur Planning time index (PTI) is high because there Planning time (PT) is more.



For the analysis, Mirpur 2 to Mirpur 10 were chosen. Wednesday morning Mirpur 2 to Mirpur 10 Planning time (PT), 13.9 min and Free flow travel time 2.55 min Planning time index (PTI) is 5.45. Wednesday off-peak Mirpur 2 to Mirpur 10 Planning time (PT), 9 min and Free flow travel time 2.55 min Planning time index (PTI) is 3.53. Wednesday evening Mirpur 2 to Mirpur 10 Planning time (PT), 17 min and Free flow travel time 2.55 min Planning time index (PTI) is 6.67. Thursday morning Mirpur 2 to Mirpur 10 Planning time (PT), 8 min and Free flow travel time 2.55 min Planning time index (PTI) is 3.14. Thursday off-peak Mirpur 2 to Mirpur 10 Planning time (PT), 5.9 min and Free flow travel time 2.55 min Planning time index (PTI) is 2.31. Thursday evening Mirpur 2 to Mirpur 10 Planning time (PT), 17.9 min and Free flow travel time 2.55 min Planning time index (PTI) is 7.02. Friday morning Mirpur 2 to Mirpur 10 Planning time (PT), 14.9 min and Free flow travel time 2.55 min Planning time index (PTI) is 5.84. Friday off-peak Mirpur 2 to Mirpur 10 Planning time (PT), 11.9 min and Free flow travel time 2.55 min Planning time index (PTI) is 4.67. Friday evening Mirpur 2 to Mirpur 10 Planning time (PT), 15.9 min and Free flow travel time 2.55 min Planning time index (PTI) is 6.24. In Thursday evening Mirpur 2 to Mirpur 10 Planning time index (PTI) is high because there Planning time (PT) is more.



For the analysis, Mirpur 10 to Mirpur 14 were chosen. Wednesday morning Mirpur 14 to Mirpur 10 Planning time (PT),12.9 min and Free flow travel time 3.45 min Planning time index (PTI) is 3.74. Wednesday off-peak Mirpur 14 to Mirpur 10 Planning time (PT),8.9 min and Free flow travel time 3.45 min Planning time index (PTI) is 2.58. Wednesday evening Mirpur 14 to Mirpur 10 Planning time (PT),12.9 min and Free flow travel time 3.45 min Planning time index (PTI) is 3.74. Thursday morning Mirpur 14 to Mirpur 10 Planning time (PT),11.9 min and Free flow travel time 3.45 min Planning time index (PTI) is 3.45. Thursday off-peak Mirpur 14 to Mirpur 10 Planning time (PT),8.9 min and Free flow travel time 3.45 min Planning time index (PTI) is 2.58. Thursday evening Mirpur 14 to Mirpur 10 Planning time (PT),11 min and Free flow travel time 3.45 min Planning time index (PTI) is 3.19. Friday morning Mirpur 14 to Mirpur 10 Planning time (PT),6.9 min and Free flow travel time 3.45 min Planning time index (PTI) is 2.0. Friday off-peak Mirpur 14 to Mirpur 10 Planning time (PT),6.9 min and Free flow travel time 3.45 min Planning time index (PTI) is 2.0. Friday evening Mirpur 14 to Mirpur 10 Planning time (PT),9 min and Free flow travel time 3.45 min Planning time index (PTI) is 2.61. In Wednesday morning Mirpur 14 to Mirpur 10 and Wednesday evening Mirpur 14 to Mirpur 10 Planning time index (PTI) is high because there Planning time (PT) is more.

CHAPTER VI

CONCLUSION

6.1 General

The reliability of travel is vital for commuters to plan trips. As public transit services are the most used mode of travel in most small cities and urban areas, the reliability of transit services is of equal importance. In this regard, reliability analysis is conducted in two folds; (i) reliability analysis of the public transit service of a study route and (ii) Travel time reliability analysis of a route considering the bus as a probe vehicle. The study is carried out in Dhaka, Bangladesh. Analysis of a few parameters such as headway, passenger waiting time, and speed & travel time in free flow, running, and peak hours scenario is conducted.

A few reliability parameters defined by FHWA namely Buffer Time Index (BTI), Average Travel Time (ATT), and Planning Time Index (PTI) of the bus route is estimated.The values indicate the reliability is low compared to other cities. The analysis was conducted using limited data such as location and schedule data, highlighting the application of the location data in a cost-effective way for locations that lack additional data sources and traffic-related infrastructure. There are several similar cities like Dhaka in Bangladesh, and other countries, and the analysis and recommendations presented can be extended to other cities in the future.

6.2 Limitation

Limitation of the Study & Recommendation for Future Study Although the study was done thoroughly but there were some limitations. The limitations were as follows:

1) **Traffic Conditions**:

   Bus travel time is heavily influenced by traffic conditions. Variability in traffic patterns, congestion, and unexpected incidents on the road can affect the reliability of bus schedules. It may be challenging to accurately predict and model these dynamic factors.

2) **Operational Issues:**

   Bus operations are subject to various operational challenges, such as mechanical failures, driver issues, and maintenance delays. These factors can lead to fluctuations in travel times and affect the overall reliability of bus services.

3) **Passenger Boarding and Alighting:**

The time it takes for passengers to board and alight from buses can vary based on factors like the number of passengers, their mobility, and the efficiency of the boarding process. This variability can introduce uncertainty into travel time predictions.

4) **Data Accuracy:**

The reliability of any analysis is contingent on the accuracy and completeness of the data used. Inaccuracies in bus arrival and departure times, as well as missing data points, can impact the precision of reliability assessments.

5) **Infrastructure Changes:**

Construction projects, road closures, or changes in infrastructure can have a significant impact on bus travel times. These changes may not be predictable in the long term, making it challenging to develop reliable models.

6) **Schedule Adherence:**

The extent to which buses adhere to their published schedules can vary. Delays in departure or early arrivals can impact the perceived reliability of the service.

7) **Data Availability and Quality:**

Availability and quality of data on bus movements, schedules, and external factors (like traffic) may vary. Limited access to real-time data or low-quality data can hinder the accuracy of reliability assessments.

8) **Spatial and Temporal Variability:**

Bus travel time reliability can vary spatially and temporally. Certain routes or time periods may be more prone to delays, and capturing this variability accurately can be challenging.

6.3 Recommendation

Improving bus travel time reliability involves addressing various factors that can contribute to delays and disruptions. Here are some recommendations to enhance bus travel time reliability:

1. Real-time Data and Communication:

- Implement real-time tracking systems for buses to provide accurate arrival and departure times.

- Disseminate real-time information to passengers through mobile apps, websites, and at bus stops.

2. Traffic Management:

- Collaborate with local traffic management authorities to optimize traffic signal timing for buses, providing them with priority at intersections.

- Implement bus lanes and exclusive bus corridors to minimize congestion and improve travel times.

3. Predictive Analytics:

- Utilize data analytics and machine learning to predict potential delays based on historical data, traffic patterns, and external factors (e.g., events, weather).

- Adjust schedules dynamically based on predicted delays to maintain reliability.

4. Bus Stop Infrastructure:

- Design bus stops with adequate shelter, seating, and real-time information displays to enhance the overall passenger experience.

- Consider off-board fare collection to reduce dwell time at stops.

5. Fleet Management:

- Regular maintenance of buses to reduce breakdowns and unexpected service interruptions.

- Invest in a modern and reliable fleet with features such as low-floor boarding, which speeds up boarding and alighting processes.

6. Schedule Optimization:

- Review and adjust bus schedules based on actual travel times, ensuring realistic buffer times for potential delays.

- Use computer-aided dispatch systems to monitor and optimize routes in real-time.

7. Training and Employee Satisfaction:

- Provide ongoing training for bus drivers on efficient driving techniques and customer service.

- Address driver concerns, ensuring job satisfaction, and minimizing turnover.

8. Multi-Modal Integration:

- Enhance integration with other modes of transportation, such as trains, subways, and bike-sharing, to create a seamless transit network.

- Facilitate easy transfers between different modes of transportation.

9. Public-Private Partnerships:

- Collaborate with private companies for innovative solutions, such as using data from ride-sharing services to optimize routes or deploying autonomous vehicles for specific routes.

10. Community Engagement:

- Involve the community in decision-making processes and gather feedback to identify specific pain points and areas for improvement.

- Encourage public support for transit initiatives through education and awareness campaigns.

Implementing a combination of these recommendations can help improve bus travel time reliability, providing a more efficient and predictable transit system for passengers. Regular monitoring and adjustment based on feedback and data analysis are essential for ongoing success.

REFERENCE

[1] R. H. M. b. K. H. c. Harsha M.M a, "Analysis of Bus Travel Time Variability using Automatic Vehicle," *World Conference on Transport Research - WCTR,* p. 2, 2019.

[2] S. I. O. E. E. M. G. Rafiu O. Olorunnimbe*, "Analysis of effects of prolonged travel delay on public bus operators' profit margin in metropolitan Lagos, Nigeria," *Journal of Sustainable Development of Transport and Logistics,* vol. 1, no. 7, p. 117, 2021.

[3] T. N. S. L. Nowakowski, *Oficyna Wydawnicza Politechniki Wrocławskiej:Wrocław, Poland,* no. 1, p. 3, 2011.

[4] R. Str., "The Problem of Reliability in Public Transport for the Metropolis," *Agnieszka Gaschi-Uciecha,* Vols. 41-800 Zabrze, pp. 26-28.

[5] M. H. R. J. A. R. S. H. S. I. MST. SONIA AKTHER PUSPO, "PREDICTING AND ANALYZING BUS SERVICE," Sonargaon University (SU), 147/I, Green Road, Dhaka-1215, Bangladesh, 2022.

[6] D. Anowar Hossain, Interviewee, *Traffic disorder brings Dhaka city to a halt.* [Interview]. 05 April 2022.

[7] D. Anowar Hossain, Interviewee, *Traffic disorder brings Dhaka city to a halt.* [Interview]. 05 Apr 2022, 19: 10.

[8] J. S. b. a. G. P. c. Johar Amita a*, "Prediction of Bus Travel Time using ANN: A Case Study in Delhi," *11th Transportation Planning and Implementation Methodologies for Developing Countries,* , p. 263 – 272, 2014.

[9] V. P. G. Y. Angelina Makria, "Critical travel time impact factors at the implementation of the Athens Great Walk," *Transport Research Arena (TRA) Conference,* pp. 1-8, 2023.

[10] Y. Deng, X. Liu, X. Hu and M. Zhang, "Reduce bus bunching with a real-time speed control algorithm considering heterogeneous roadway conditions and intersection delays," *J. Transp. Eng. A Syst,* vol. 04020048, p. 146, 2020.

[11] Y. Gu, X. Fu, Z. Liu, X. Xu and Chen, "A. Performance of transportation network under perturbations: Reliability, vulnerability, and resilience.," *Transp. Res. E*

Logist. Transp. Rev., vol. 101809, p. 133, 2020.

[12] T. K. T. S. ,. A. Ravi Sekhar CHALUMURI, "EXAMINING TRAVEL TIME RELIBILITY ON HAN-SHIN," *Journal of the Eastern Asia Society for Transportation Studies,* vol. 7, pp. 2-16, 2007.

[13] ,. L. D. V. M. B. S. Jijo K. Mathewa, "Investigation of the Use of Bluetooth Sensors for travel Time Studies under Indian Conditions," *Transportation Research Procedia,* vol. 17, pp. 213-222, 2016.

[14] "LatLong.net," [Online]. Available: https://www.latlong.net/place/uttara-dhaka-bangladesh-971.htm.

[15] S. P. &. K. Koilada, "Exploring Correlations between Travel Time Based Measures by Year, Day-of-the-week, Time-of-the-day, Week-of-the-Year and the Posted Speed Limit," *Urban, Planning and Transport Research,* vol. 9, no. 1, pp. 1-17, 2021.

[16] fhwa, "Federal Highway Administration," U.S. Department of Transportation, [Online]. Available: https://ops.fhwa.dot.gov/publications/tt_reliability/ttr_report.html.

[17] T. C. A. M. a. S. K. R. Saptarshin Sen, "Assessing Travel Time Reliability of Public Transport in Kolkata: A Case Study," *https://www.researchgate.net/publication/332988562_,* p. 22, May,2019.

[18] J. W. ,. A. D. W. ,. Q. ,. B. Alan Danaher, "Developing a Guide to Bus Transit Service Reliability," Washington,DC, National Acadenies, 2020, pp. 1-262.