TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PASHCHIMANCHAL CAMPUS

A PROJECT REPORT

ON

MeroBus Navigator: An Approach to Smart Public Transportation System in Pokhara

SUBMITTED BY

Bibek Kandel (PAS076BGE008)   Hemant Kumar Mahatara (PAS076BGE017)

Keshav Bdr.Bhujel (PAS076BGE019)   Niranjan Bhattarai (PAS076BGE027)

Sagun Tripathi (PAS076BGE035)

SUBMITTED TO THE DEPARTMENT OF GEOMATICS ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE BACHELOR'S DEGREE IN GEOMATICS ENGINEERING

PASHCHIMANCHAL CAMPUS

POKHARA, NEPAL

April, 2024

DECLARATION

We hereby declare that the project entitled "**MeroBus Navigator: An Approach to Smart Public Transportation System in Pokhara**" submitted to the Department of Geomatics Engineering, Pashchimanchal Campus, Institute of Engineering, Tribhuvan University, is our original piece of work done under the supervision of Asst. Prof., Er. Bikash Sherchan and is submitted in partial fulfilment of the requirements for the Bachelor's Degree in Geomatics Engineering. All sources of information used for this project have been duly acknowledged and cited. We take full responsibility for any errors or omissions contained herein.

BIBEK KANDEL
PAS076BGE008

HEMANT K. MAHATARA
PAS076BGE017

KESHAV BDR. BHUJEL
PAS076BGE019

NIRANJAN BHATTARAI
PAS076BGE027

SAGUN TRIPATHI
PAS076BGE035

ABSTRACT

This project focuses on the development and implementation of a Smart Bus Tracking System (SBTS) in Pokhara Valley, Nepal, aimed at enhancing public transportation accessibility and efficiency. The centrepiece of this initiative is the "MeroBus Navigator" mobile application, designed to provide commuters with real-time bus tracking capabilities, predictive bus arrival times, and fare integration features. Through the utilization of GPS technology and communication modules, the SBTS enables users to monitor bus movements, plan journeys more effectively, and streamline the ticketing process. A preliminary study was conducted to gather information on the existing public bus management system in Pokhara Metropolitan City, including bus routes, schedules, and fare structures. Data collection methods included interviews with transportation authorities and surveys among commuters to assess current challenges and preferences. Subsequently, the SBTS was developed using a combination of hardware components, including SAM-M8Q and GSM modules, integrated with the ESP-32 microcontroller. The implementation of the SBTS has yielded several notable outcomes, including improved commuter experience, convenience in fare management, enhanced route information, increased accessibility, and enhanced engagement through feedback mechanisms. Furthermore, the project's environmental impact analysis demonstrates the potential reduction in air pollution by replacing private vehicle usage with public transportation services. In conclusion, the SBTS represents a significant advancement in urban mobility solutions for Pokhara Valley, offering a sustainable and technology-driven approach to public transportation management. The project's success underscores the importance of leveraging smart technologies to address urban transportation challenges and promote a cleaner, more efficient transportation ecosystem.

KEYWORDS: ESP-WROOM-32, GSM/GPRS, GNSS, Smart Buses Tracking System (SBTS), SparkFun SAM-M8Q

ACKNOWLEDGEMENT

We have taken immense efforts of ourselves in this project. However, it would not have been possible without the kind support and help of many individuals and organizations. We would like to extend our sincere thanks to all of them. We are very indebted to the Department of Geomatics Engineering, Pashchimanchal Campus for providing us the opportunity to be a part of final year project. We are very thankful to our supervisor Asst. Prof., Er. Bikash Sherchan for his continuous support and guidance. We are truly grateful to Pokhara Transportation Pvt. Ltd. for providing such information related to the route and bus fare in Pokhara Valley. We would also like to appreciate our Head of Department Asst. Prof., Er. Umesh Bhurtyal for providing us his valuable time and support. We are thankful to Er. Suraj Shrestha from Pokhara Transportation Pvt. Ltd., Dhiraj Chaurasiya and Binish Shrestha for their valuable time and support for this project.

At last, we thank to all those people who were involved directly or indirectly in this project to complete it. Thanks to everyone for your valuable time and support.

CERTIFICATE OF APPROVAL

The undersigned certify that we have read, and recommended to the Institute of Engineering for the acceptance, a project entitled **“MeroBus Navigator: An Approach to Smart Public Transportation System in Pokhara”** submitted by Mr. Bibek Kandel, Mr. Hemant K. Mahatara, Mr. Keshav Bdr. Bhujel, Mr. Niranjan Bhattarai and Mr. Sagun Tripathi in partial fulfillment of the requirement for the degree of Bachelor's in Geomatics Engineering.

No part of this work has been submitted to any other institute or university.

We recommend that the project be considered for the evaluation leading to the award of Bachelor’s Degree of Geomatics Engineering.

____

Asst. Prof., Er. Umesh Bhurtyal

Head of Department

Department of Geomatics Engineering

____

External Examiner

Er. Shova Acharya

Survey Officer

Date: 05 May, 2024

TABLE OF CONTENTS

LIST OF FIGURE

LIST OF TABLES

LIST OF ABBREBRATION

2G	Second generation
API	Application Programming Interface
C/A	Coarse acquisition
GALILEO	Europe’s Satellite Navigation System
GeoJSON	Geographic JavaScript Object Notation
GIS	Geographic Information System
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System
GPRS	General packet radio service
GPS	Global Positioning System
GSM	global system for mobile communications
HDOP	Horizontal Dilution of Precision
HTTP	Hypertext Transfer Protocol
IRNSS	India’s Regional Navigation Satellite System
JSON	JavaScript Object Notation
MSL	Mean Sea level
NMEA	National Marine Electronics Association
OSM	Open Street Map
QZSS	Japan’s Quasi-Zenith Satellite System
RTK	Real-Time Kinematic
SBTS	Smart Bus Tracking System
SCL	Serial Clock Line
SDA	Serial Data Line
SIM	Subscriber Identity Module
SQL	Structured Query Language
UART	Universal Asynchronous Receiver-Transmitter
WGS	World Geodetic System

CHAPTER 1 INTRODUCTION

1.1 Background

The public transportation system is the primary issue that arises when traveling for various reasons and is becoming more and more significant. It is an incredibly economical kind of transportation. The majority of buses arrive late due to traffic jams, construction projects, and other factors. People are forced to wait for a very long time at the bus terminus without even knowing when the bus will arrive. If someone want to take public transportation, they are unable to determine when a specific bus will arrive at their residence and adjust their departure time accordingly. It is not possible to confirm the exact time of bus arrival owing to unforeseen delays caused by traffic congestion.

In the busy metropolitan cities like Kathmandu and Pokhara, people don't have time to invest in waiting for transport. Waiting time for transport in such crowded cities leads to less productivity on a whole. People face this problem in their daily life where they have no idea about the current status of their transport. So, the proposed solution is an android based application that will help the user to check out the current location of the bus and also will help the user to know how much time the bus will take to reach the current location of the user. The system will use GNSS as the basis for the application and basic android application will be interfacing with the updated database to provide the real-time data to the user, hence enhancing the user-experience.

There are buses accessible to transport people to various areas, however not all passengers are fully aware of these busses. Comprehensive details, such as the number of buses that travel to the desired location, the bus's number, its timings, the routes it will travel, and the amount of time it will take the vehicle to arrive at its destination, will help passengers find their way around, track the bus's current location, and provide the exact time it will arrive at its destination. The above-mentioned issues are addressed by the suggested system. The system is an Android application that provides all the information needed to know about every bus that travels through Pokhara. The Android operating system was selected as the platform for this type of system since it has become widely available and is owned by nearly everyone. Since the Android operating system's release, a growing number of large-scale applications have been built for it every day.

1.2 Statement of the Problem

Pokhara Valley, a popular tourist destination with distinctive topography, has serious issues with the effectiveness and dependability of its public transportation system. Buses do not currently have real-time tracking or information dissemination, which leads to a number of problems like unreliable arrival times, ineffective route planning, and a less than ideal passenger experience. In order to address these issues, this project will install a thorough real-time bus tracking system in Pokhara Valley. An app will be created to display the bus's route, arrival time, and other details.

Key Issues:

i. **Inconsistent Arrival Times**: Passengers in Pokhara Valley experience uncertainty and delays in bus arrival times due to the absence of a real-time tracking system.

ii. **Limited Information Availability:** The lack of a centralized information platform makes it difficult for commuters to access real-time updates on bus locations and bus fare leading to frustration and inconvenience.

iii. **Operational Inefficiencies:** Bus operators face difficulties in managing and optimizing their fleets due to a lack of real-time data on bus movements, resulting in suboptimal route planning and resource allocation.

iv. **Geographical Challenges:** The unique topography of Pokhara Valley, with uncertain climate and varying terrain, poses challenges to accurate GNSS tracking, necessitating a customized solution tailored to this region.

This project seeks to address these issues through the implementation of a state-of-the-art real-time bus tracking system, ultimately contributing to the improvement of the public transportation landscape in Pokhara Valley.

1.3 Objective

1.3.1 General objective:

To develop a Smart Bus Tracking System (SBTS) using GNSS receiver and mobile app in Pokhara valley.

1.3.2 Specific Objectives:

- To develop a reliable real-time bus tracking system that provides accurate location information effective public transport.
- To locate the bus station within the 5km radius from the current location of user and also helps in calculating the bus fare between source and destination.

1.4 Limitation of the Study

There are some limitations that could potentially affect this study to enhance the public transportation system in Pokhara valley. Some of these limitations include:

i. **Traffic and Route Variability:** Traffic conditions and route changes due to road maintenance or events have affected the accuracy of predicted arrival times. Developing algorithms that can adapt to real-time changes in traffic and routes is crucial.

ii. **Availability of data:** The data available for the bus network, bus fare within the area and tracking of the bus is not clear and understandable.

iii. **Geographical Challenges:** Pokhara Valley's terrain in some places pose challenges for GNSS accuracy, especially in densely populated and forested areas. The system should account for these geographical challenges to provide accurate tracking.

1.5 Scope of the Study

The goal of the project is to use React Native to create and deploy a real-time location monitoring system for public transportation in Nepal's Pokhara Metropolitan City. By giving users the opportunity to track both their present location and the real-time location of buses outfitted with SBTS Signal, this system seeks to improve the general efficiency and accessibility of public transportation. By using such cutting-edge GNSS technology, the buses' location is guaranteed to be precise and dependable, giving users the ability to plan their travel itineraries and schedules with confidence.

In addition, the project includes the integration of a dynamic map interface that shows the specific bus routes in the Pokhara Metropolitan City in addition to the bus positions as of right now. By offering a thorough grasp of the public transportation system, this element improves the user experience by assisting with route planning and reducing travel uncertainty. The application's user-friendly layout tries to accommodate Pokhara's diverse population by providing both locals and visitors with an easy and effective way to commute.

The study also looks at how this technological solution can affect Pokhara's passenger mentality and the city's broader transportation system. The project aims to evaluate the efficacy of the installed solution by gathering and evaluating data on user involvement, route optimization, and the dependability of the location monitoring system. The study's conclusions can help shape system improvements in the future and provide important information for urban transportation planning in the context of expanding metropolises like Pokhara.

1.6 Study Area

The study area for this project is Pokhara metropolitan city of Gandaki province, situated in the western part of Nepal with a latitude and longitude of 28.2096° N, 83.9856° E respectively. Pokhara, a major city in central Nepal, is the administrative centre of the Gandaki Province. After Kathmandu, it has the second-highest population in Nepal. Pokhara's metro area will have 476,000 residents in 2023, an increase of 3.93% from 2022. Pokhara's metro area had a population of 458,000 in 2022, up 4.33% from 2021. Pokhara's metro area had 439,000 residents in 2021, up 4.28% from the previous year. In terms of size, it is the largest metropolitan area in the nation. The city also houses the Kaski District's administrative centre. Pokhara is situated 200 kilometres (120 miles) west of Kathmandu, the country's capital. The city is located at an elevation of roughly 822 meters and is situated on the Shore of Phewa Lake. Within 15-35 miles (24-56 km) of the valley is the Annapurna Range, which is home to three of the ten highest mountains in the world: Dhaulagiri, Annapurna I, and Manaslu. Pokhara is considered the tourism capital of Nepal, being a base for trekkers undertaking the Annapurna Circuit through the Annapurna Conservation Area region of the Annapurna ranges in the Himalayas.

The valley is crisscrossed by different types of roads, including a National Highway spanning 13.2 km, Major Roads covering 12.6 km, Connector Roads totalling 107.23 km, and Access Roads stretching over 451.5 km. Three main bus parks—Pokhara, Tourist, and Baglung—serve as central nodes for commuting. With approximately 400 city buses and mini-buses, alongside 150 micro-buses, locals enjoy ample choices for getting around. Tourists, on the other hand, have access to 75 designated tourist buses for exploring the valley's attractions.

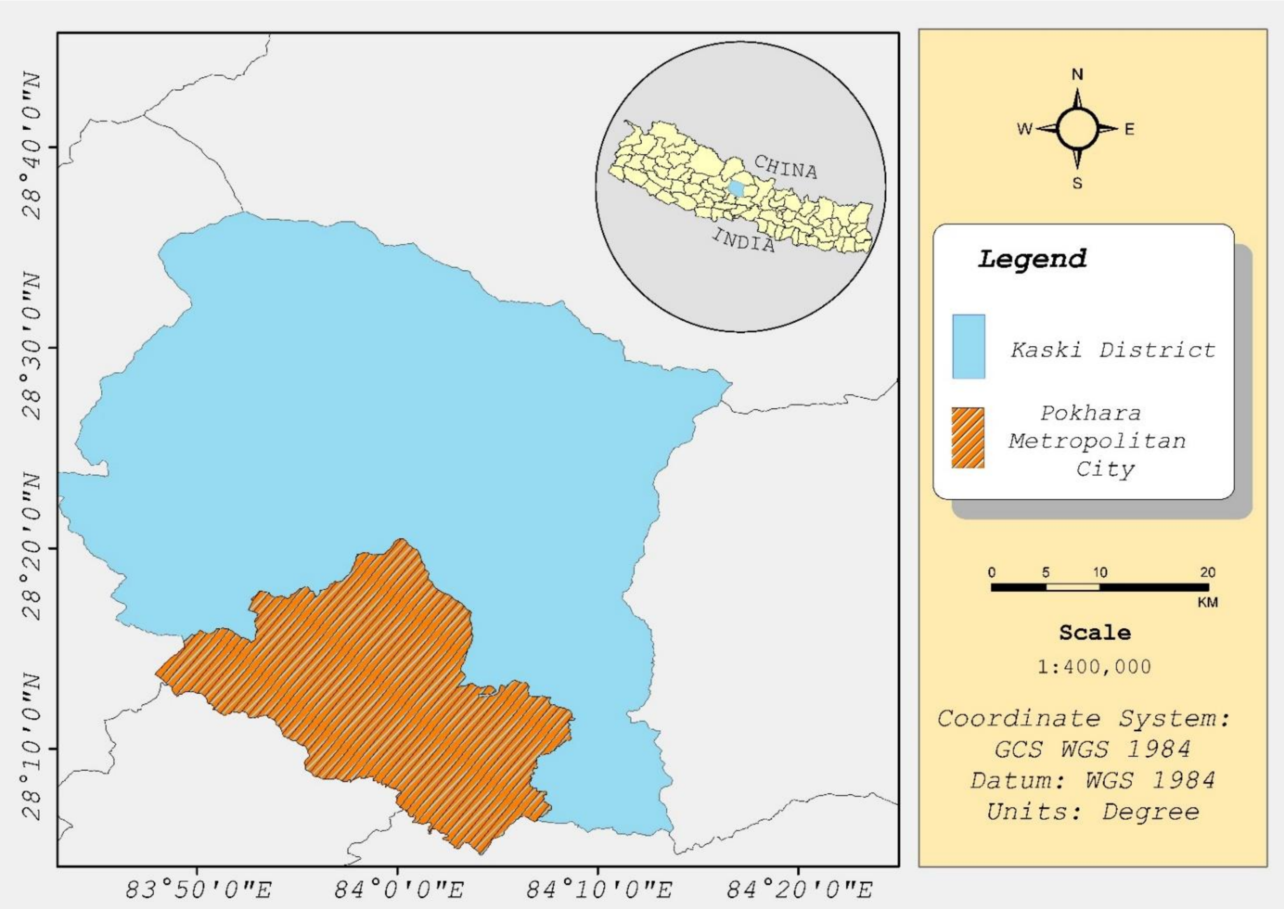


Figure 1-1: Study Area - Pokhara Metropolitan City

CHAPTER 2 LITERATURE REVIEW

Public transportation management has evolved significantly with the advent of mobile applications aimed at enhancing commuting experiences. This evolution is underpinned by a rich body of literature that explores various facets of technology integration, user experience, system optimization, and the broader impact on urban mobility. One pivotal area of research, as highlighted by Johnson et al. (2020), delves into the utilization of Global Navigation Satellite System (GNSS) tracking in public transport management. Their study underscores the transformative role of real-time location data in optimizing bus routes, streamlining operations, and ultimately improving the overall passenger experience by providing accurate and up-to-date information to commuters and operators alike.

Complementing this technological advancement, Smith and Brown (2019) shed light on the benefits of fare integration and cashless transactions within public transport ecosystems. Their research emphasizes the seamless and efficient fare payment options facilitated by mobile apps, contributing to smoother transactions, reduced queuing times, and enhanced convenience for commuters. This shift towards digital payment solutions aligns with broader trends in digital transformation within the transportation sector, fostering a more agile and responsive public transport infrastructure.

Moreover, in the realm of user experience and adoption rates, Yang and Wu (2021) conducted an in-depth analysis of mobile application usage in the transportation sector. Their findings underscore the critical importance of user-friendly interfaces, intuitive functionalities, and personalized features in driving user adoption and engagement. The study highlights the need for mobile apps to cater to diverse user preferences and behaviour, thereby enhancing user satisfaction and retention rates, which are crucial for the long-term success of public transport initiatives.

Real-time information accessibility has emerged as a game-changer in commuter behaviour, as revealed by Lee et al. (2018). Their research showcases how access to timely data, such as real-time bus locations and arrival times provided by mobile transportation apps, significantly influences commuting decisions. This access not only reduces wait times and uncertainties but also fosters a sense of reliability and trust among commuters, ultimately leading to a more seamless and efficient travel experience.

Efficient route planning algorithms play a pivotal role in optimizing commute experiences, as emphasized by Wang et al. (2020). Their study underscores the significance of accurate route predictions, dynamic routing options, and optimization algorithms in reducing travel times, minimizing congestion, and enhancing overall commute experiences. These advancements are particularly crucial in urban areas with complex transport networks and high commuter volumes, where efficient route planning can alleviate congestion and improve the overall flow of traffic.

Furthermore, Chen and Li (2019) provide valuable insights into the integration of machine learning techniques for commuter analytics. By leveraging data analytics and machine learning algorithms, transport authorities can gain valuable insights into commuter patterns, preferences, and behaviour. This data-driven approach enables personalized services, improved operational efficiency, and targeted interventions to enhance service delivery within mobile applications.

In addition to these foundational studies, a broader spectrum of research has contributed diverse perspectives and innovative solutions to the field. For instance, Zhang and Liu (2020) explored the integration of intelligent transportation systems with mobile apps to facilitate seamless commuting experiences. Their research underscores the potential synergies between intelligent systems and user-centric mobile solutions, paving the way for more efficient and responsive transport networks.

Moreover, Park et al. (2019) focused on the integration of multimodal transportation options within mobile apps, providing commuters with comprehensive commuting solutions that cater to diverse transport modes and preferences. This multimodal approach not only enhances connectivity but also promotes sustainable and efficient travel choices among commuters.

Gamification strategies within mobile transportation apps have also garnered attention, as demonstrated by Kim and Lee (2021). Their study showcases how gamification elements can enhance user engagement, promote sustainable commuting behaviours, and incentivize active participation within the transport ecosystem. These gamified experiences foster a sense of achievement and reward, encouraging users to adopt more eco-friendly travel options and contribute to reducing carbon footprints.

The inclusivity and accessibility aspects of mobile transportation apps were addressed in Martinez et al.'s (2020) study, highlighting the importance of inclusive design principles and accessibility features. This ensures equitable access to public transport services for users with disabilities and special mobility needs, fostering an inclusive and accessible urban transport environment.

Dynamic pricing strategies (Chen et al., 2017) based on demand and congestion levels can incentivize off-peak travel, optimize resource utilization, and contribute to a more efficient and sustainable transport system overall. Crowdsourcing and real-time updates (Li & Wang, 2019) from users can significantly enhance the accuracy, reliability, and responsiveness of mobile transportation apps, providing valuable information for informed decision-making and improved service delivery.

Personalized recommendation algorithms (Gupta & Sharma, 2021) within mobile apps can further enhance user experiences by providing tailored recommendations, personalized services, and customized travel options based on user preferences and behaviour. Safety and security features (Kim et al., 2018) play a crucial role in ensuring passenger safety, building trust, and enhancing confidence in using public transport services.

Lastly, the integration of mobile transportation apps with broader smart city initiatives (Singh et al., 2020) holds immense potential for creating interconnected, intelligent, and sustainable urban mobility solutions. By leveraging data-driven insights, innovative technologies, and collaborative platforms, cities can optimize transport systems, reduce congestion, and improve the overall quality of life for residents.

Incorporating insights from these diverse studies enriches the literature review by showcasing the multifaceted approaches, technological advancements, user-centric strategies, and collaborative efforts involved in developing, implementing, and improving mobile applications for public transport management and commuting enhancement.

CHAPTER 3 METHODOLOGY

This section outlines the methodology used to carry out the project and achieve its objectives. It consist of a detailed description of the procedures used to collect, analyse and interpret the data. The work-flow adopted to accomplish this project work is illustrated in Figure 2.

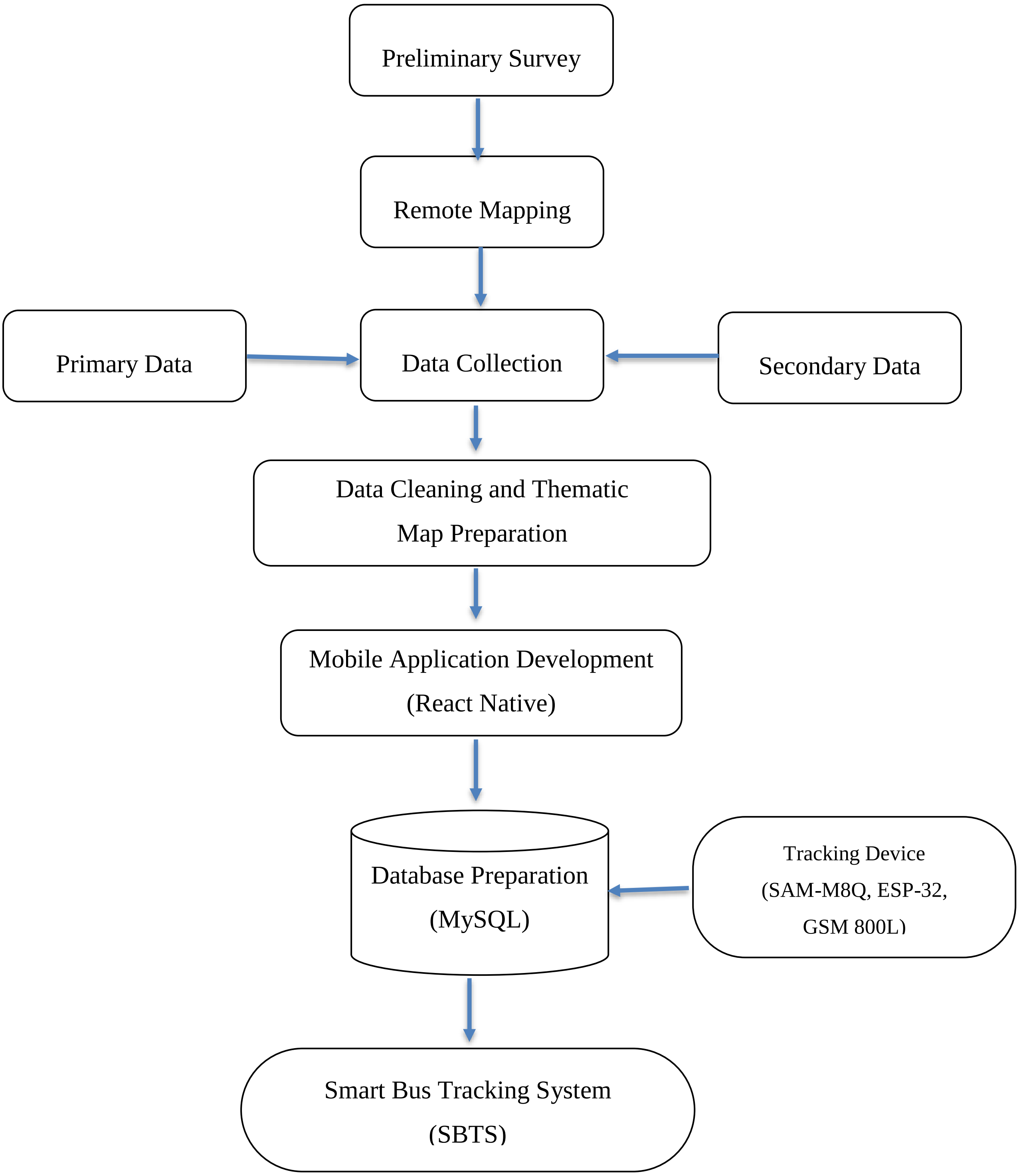


Figure 3-1: Workflow for Smart Bus Tracking System (SBTS)

The core of our real-time tracking system is based on GNSS technology, which is the basis for tracking users' current locations via the mobile application. Utilizing GNSS guarantees precise and dynamic positioning data, giving users a real-time sense of where they are in the Pokhara Metropolitan City. In addition, we have implemented a Real-Time Public Buses Tracking System Using GNSS and GPRS to improve the accuracy and dependability of the bus tracking system. This cutting-edge technology delivers accurate location updates every second when it is installed in public transportation vehicles through the use of Real-Time Kinematic (RTK) technology. Then, the device seamlessly transmits and updates this real-time data to the server and display on the application, which includes the bus's current location and speed. Our project guarantees a reliable and accurate real-time tracking experience by utilizing this particular combination of GPS and GNSS technologies, providing users with an extensive overview of Pokhara's public transportation system.

3.1 Preliminary Study

In the preliminary study phase, we initiated the project by conducting thorough research to gather essential information and establish a solid foundation for the project implementation. Beyond examining the overall structure of the public bus management system in Pokhara Metropolitan City, we also explored specific aspects crucial for the development of our Smart Bus Tracking System (SBTS). We started by comprehensively studying the public bus management system operating within Pokhara Metropolitan City.

This involved analysing the organizational structure, operational procedures, and regulatory framework governing public transportation. We conducted interviews and consultations with key stakeholders, including officials from Pokhara Transportation Pvt. Ltd. to gain insights into the functioning of the existing system and identify areas for improvement. To facilitate data collection, we collaborated closely with Pokhara Transportation Pvt. Ltd., the primary authority responsible for managing and monitoring public buses in the Pokhara valley. By leveraging the cooperation of the transportation company, we obtained extensive information pertaining to bus routes, schedules, fleet management, and fare structures. This included details on the number of buses deployed, frequency of service, and fare regulations for different routes. Additionally, we conducted surveys and field observations to gather first-hand information regarding passenger demographics, travel patterns, and common pain points experienced by passengers.

3.2 Remote Mapping

Further, we extended our efforts to digitize the individual road network and identify all bus stops along every route within the Pokhara valley. We utilized geojson.io, a user-friendly platform to digitize the individual road network and pinpoint all bus stops along each route within the Pokhara valley. This web-based tool enabled us to efficiently create GeoJSON files, a standard format for encoding geographical data, to represent the road network and bus stop locations accurately. By leveraging geojson.io's intuitive interface and mapping capabilities, we streamlined the process of digitizing and visualizing spatial data essential for our Smart Bus Tracking System (SBTS). The digitized data generated through geojson.io was then seamlessly integrated into our system, facilitating map preparation and deployment onto mobile devices.

3.3 Data Collection

3.3.1 Primary Data Collection

In the primary data collection phase, our focus centred on gathering essential bus route information crucial for the development of our Smart Bus Tracking System (SBTS). To achieve this, we deployed MADOCA devices onto buses, enabling us to precisely track the routes traversed by each vehicle and monitor their respective speeds. This approach provided us with valuable insights into the movement patterns of buses within the Pokhara valley, allowing us to analyse travel times between individual stations comprehensively. By collecting data from the MADOCA devices, we could accurately determine the time taken for buses to complete their routes, thereby facilitating efficient scheduling and operational planning for public transportation services.

However, due to constraints such as limited availability of MADOCA devices, we supplemented our data collection efforts by incorporating the My Track mobile application into our methodology. This application served as an additional tracking tool, allowing us to gather route data from vehicles where MADOCA devices were not deployed. By combining the data obtained from both sources, we ensured a more comprehensive coverage of bus routes across the city. This integrated approach enhanced the reliability and accuracy of our dataset, empowering us to develop a robust and effective Smart Bus Tracking System capable of providing real-time information to commuters and stakeholders alike.

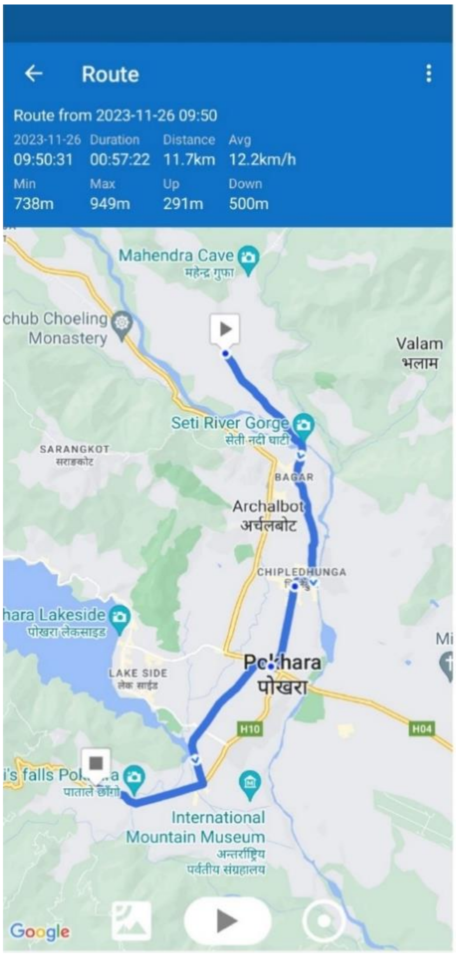


Figure 3-2: My Track App Tracking Route

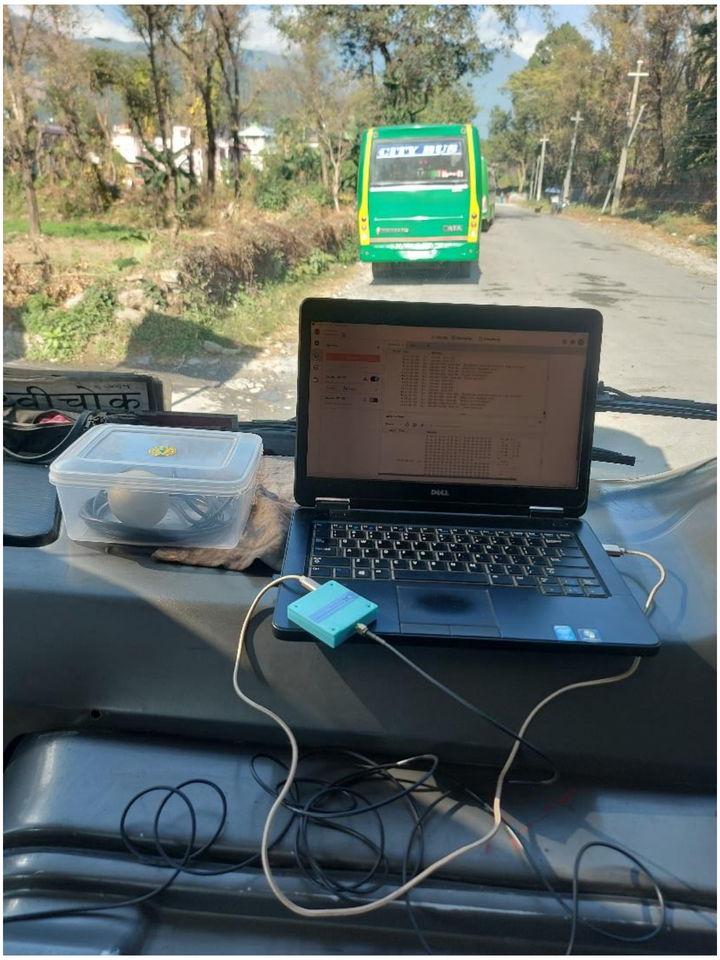


Figure 3-3: MADOCA GNSS Receiver Tracking Bus Route

In addition to our primary data collection methods, we implemented KoboCollect, a data collection tool, to gather insights from passengers using public bus services. Through surveys conducted via KoboCollect, we concentrated on understanding passengers' perspectives and experiences regarding the current state of public transportation services. Our survey encompassed various aspects including passengers' attitudes towards the service, their satisfaction levels, frequency of bus usage, and their perceptions of punctuality in bus arrival times. We aimed to determine common issues faced by commuters, such as waiting times and service reliability, in order to comprehensively assess the existing public transportation infrastructure.

The data obtained through KoboCollect surveys serves as a vital resource for analyzing the current status of public bus services and evaluating the quality of services provided. By delving into passengers' opinions and experiences, we gain valuable insights that inform our understanding of the strengths and shortcomings of the public transportation system. This information is instrumental in identifying areas for improvement and guiding future enhancements to enhance the overall quality and efficiency of public bus services in Pokhara. Through a combination of data collected from MADOCA GNSS Receiver devices, the My Track mobile application, and KoboCollect surveys, we aim to develop a holistic understanding of the public transportation landscape, ultimately contributing to the creation of a more responsive and passenger-centric Smart Bus Tracking System.

1 - 30 250 results	Validation	start	end	A)Personal Information / 1)Full Name	A)Personal Information / 2)Age	A)Personal Information / 3)Gender	A)Personal Information / 4)Occupation
	Show All	Search	Search	Search	Show All	Show All	Show All
	—	Feb 18, 2024 ...	Feb 18, 2024 ...	Kandu vai	25-30	Male	Teacher
	—	Feb 18, 2024 ...	Feb 18, 2024 ...	Hemant thapa ...	35 above	Male	others
	—	Feb 18, 2024 ...	Feb 18, 2024 ...	Resham chand	25-30	Male	Teacher
	—	Feb 18, 2024 ...	Feb 18, 2024 ...	Radha bhusal	25-30	Female	others
	—	Feb 18, 2024 ...	Feb 18, 2024 ...	Hari Gharti	20-25	Male	Students
	—	Feb 18, 2024 ...	Feb 18, 2024 ...	Sarmila karki	30-35	Female	Government Officer

Figure 3-4: Public Survey Data Collected using KoboCollect

3.3.2 Secondary Data Collection

In order to obtain comprehensive information about the transportation system in the project area, our survey team utilized both primary and secondary data collection methods. While MADOCAGNSS Receiver and the My Track app served as primary data collection tools, crucial details such as bus routes, departure schedules, bus quantities per route, and stop times at each station were obtained from the Pokhara Transportation Pvt. Ltd. This collaboration allowed us to access reliable information regarding the operational aspects of the public bus system, ensuring accuracy in route planning and scheduling. Additionally, for the road network data, we turned to the OpenStreetMap (OSM) platform, a free and open-source mapping resource. Leveraging the extensive and continuously updated data available on OSM, we obtained detailed road network information essential for route planning and analysis within the project area. By integrating both primary and secondary data sources, we ensured a comprehensive understanding of the transportation infrastructure, facilitating the development of our Smart Bus Tracking System and enhancing its effectiveness in serving the needs of commuters in Pokhara. The table 1 shows the description of the data:

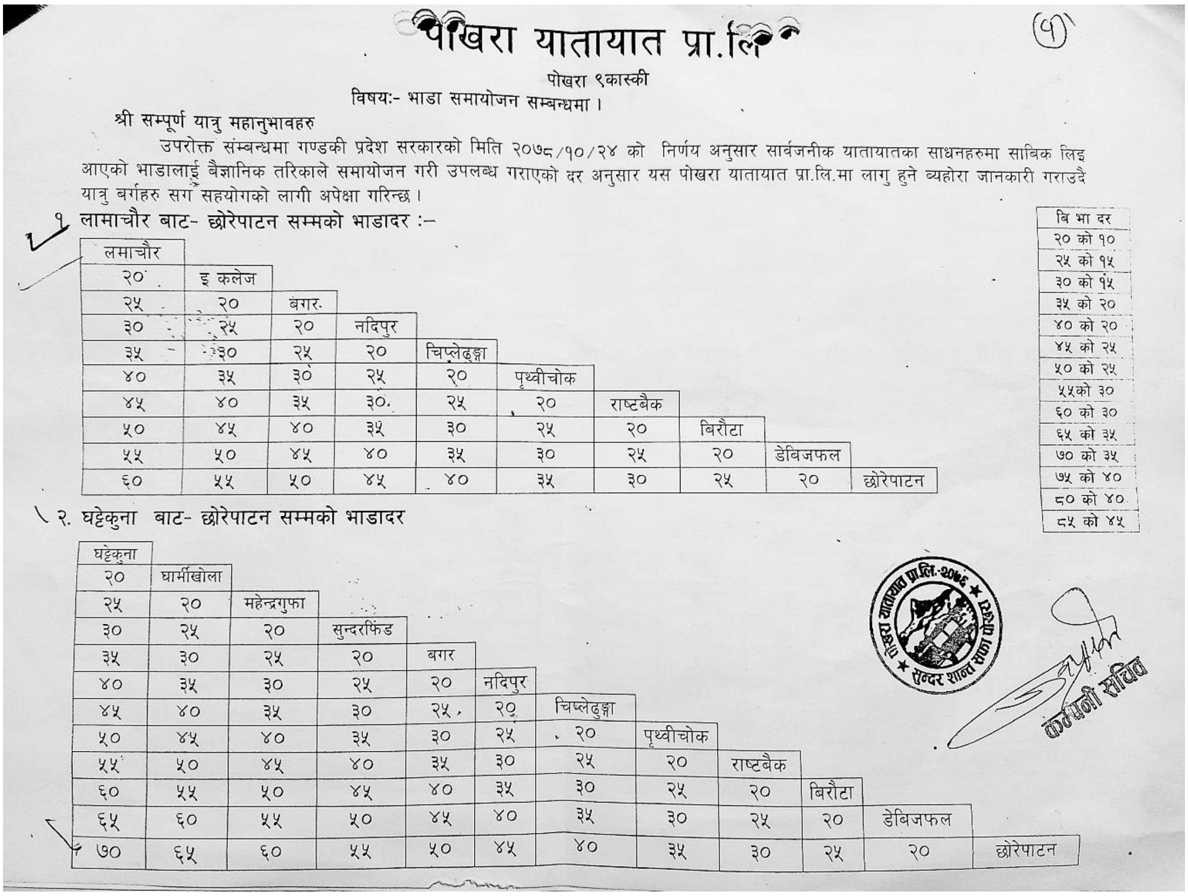
3.1 Collected Data

Table 3-1: Datasets used in the project

Data	Source	Data Type	Product
Bus routes and bus fare	Pokhara Transportation Pvt. Ltd.	Attribute Data	
Bus route and stop time	Field data collection	Vector Data	Road Network
Road network	OSM, geojson.io	Vector Data	Road network in mobile app
Real time location	Low-Cost High-Accuracy GNSS Receiver System (MADOCA), My Track	Vector Data	

3.1.1 Bus Fare Data

In our Android application designed for Pokhara Metropolitan City public transportation, we've integrated a crucial feature: the bus fare system. With valuable input from Pokhara Transportation Pvt. Ltd., we obtained comprehensive information regarding total bus fares, including special student discounts, applicable to individual routes and between bus stations. This integration enhances transparency in travel expenses and empowers users to plan their trips with greater foresight. By incorporating the fare system into our application, we aim to provide users with a comprehensive tool that not only tracks bus locations and routes but also considers the financial aspects of commuting. This initiative seeks to make public transportation more affordable and accessible to a broader demographic, thereby contributing to a more inclusive and convenient transportation experience for residents and visitors alike in Pokhara.



(५)

पोखरा यातायात प्रा.लि

पोखरा ९कास्की

विषयः- भाडा समायोजन सम्बन्धमा ।

श्री सम्पूर्ण यात्रु महानुभावहरु

उपरोक्त संम्बन्धमा गण्डकी प्रदेश सरकारको मिति २०७८/१०/२४ को निर्णय अनुसार सार्वजनीक यातायातका साधनहरुमा साबिक लिइ आएको भाडालाई बैज्ञानिक तरिकाले समायोजन गरी उपलब्ध गराएको दर अनुसार यस पोखरा यातायात प्रा.लि.मा लागु हुने व्यहोरा जानकारी गराउदै यात्रु बर्गहरु सग सहयोगको लागी अपेक्षा गरिन्छ ।

१ लामाचौर बाट- छोरेपाटन सम्मको भाडादर :–

लमाचौर									
२०	इ कलेज								
२५	२०	बगर							
३०	२५	२०	नदिपुर						
३५	३०	२५	२०	चिप्लेढुङ्गा					
४०	३५	३०	२५	२०	पृथ्वीचोक				
४५	४०	३५	३०	२५	२०	राष्टबैक			
५०	४५	४०	३५	३०	२५	२०	बिरौटा		
५५	५०	४५	४०	३५	३०	२५	२०	डेबिजफल	
६०	५५	५०	४५	४०	३५	३०	२५	२०	छोरेपाटन

बि भा दर
२० को १०
२५ को १५
३० को १५
३५ को २०
४० को २०
४५ को २५
५० को २५
५५को ३०
६० को ३०
६५ को ३५
७० को ३५
७५ को ४०
८० को ४०
८५ को ४५

२. घट्टेकुना बाट- छोरेपाटन सम्मको भाडादर

घट्टेकुना											
२०	घार्मीखोला										
२५	२०	महेन्द्रगुफा									
३०	२५	२०	सुन्दरफिंड								
३५	३०	२५	२०	बगर							
४०	३५	३०	२५	२०	नदिपुर						
४५	४०	३५	३०	२५	२०	चिप्लेढुङ्गा					
५०	४५	४०	३५	३०	२५	२०	पृथ्वीचोक				
५५	५०	४५	४०	३५	३०	२५	२०	राष्टबैक			
६०	५५	५०	४५	४०	३५	३०	२५	२०	बिरौटा		
६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	डेबिजफल	
७०	६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	छोरेपाटन

कम्पनी सचिव

Figure 3-5: Bus Fare Table (Source: Pokhara Transportation Pvt. Ltd.)

3.1.2 Road Network

The foundation of the project is heavily dependent on precise road network data, which is an essential element for efficient navigation and route planning. The widely used OpenStreetMap (OSM) platform, which is known for being open-source, was utilized to obtain this vital data. The platform provides a plethora of geographic information, such as extensive road networks and bus stop locations. Owing to the large size of OSM's dataset, a careful selection procedure was used to identify the individual roads that are relevant to Pokhara Metropolitan City's public transportation routes.

It was crucial to ensure the road network data was relevant and accurate, and Pokhara Transportation Pvt. Ltd.'s data was included for validation purposes. Through this partnership, the chosen road data was cross-checked and improved, bringing it closer to the real routes used by the community's public transportation system. The application gains a strong and accurate road network as well as an accurate representation of the city's public transportation system thanks to the integration of data from the Transportation Company and OSM. This also improves the accuracy and dependability of the navigation and tracking features in the application.

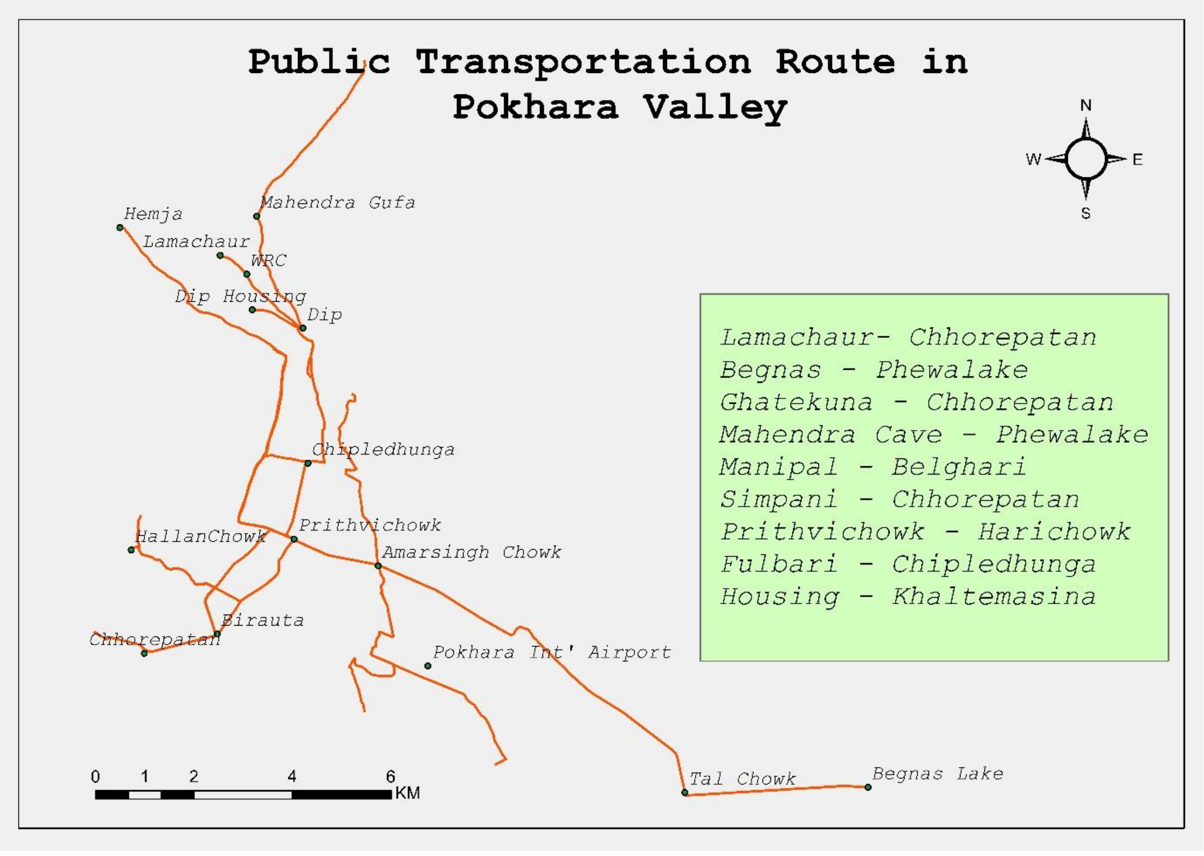


Figure 3-6: Public Transportation Route in Pokhara Valley

3.1.3 Bus Stop Time

We integrated data from the mobile app My Track to improve our application's functionality and give users up-to-date information on bus stops and dwell times at specific stations. We were able to keep track of the bus routes and accurately log the amount of time we spent at each station while traveling thanks to this app. We were able to obtain important information about the temporal features of the bus service, such as the length of stops at particular stations, by using My Track. By taking into account the actual time allotted for each stop, this data helps to improve route planning for users in addition to improving the accuracy of our application's representation of real-world bus operations. The incorporation of this time-sensitive data is consistent with our dedication to providing Pokhara Metropolitan City with a complete and dependable public transportation system that meets the complex requirements of commuters and makes effective travel planning possible.

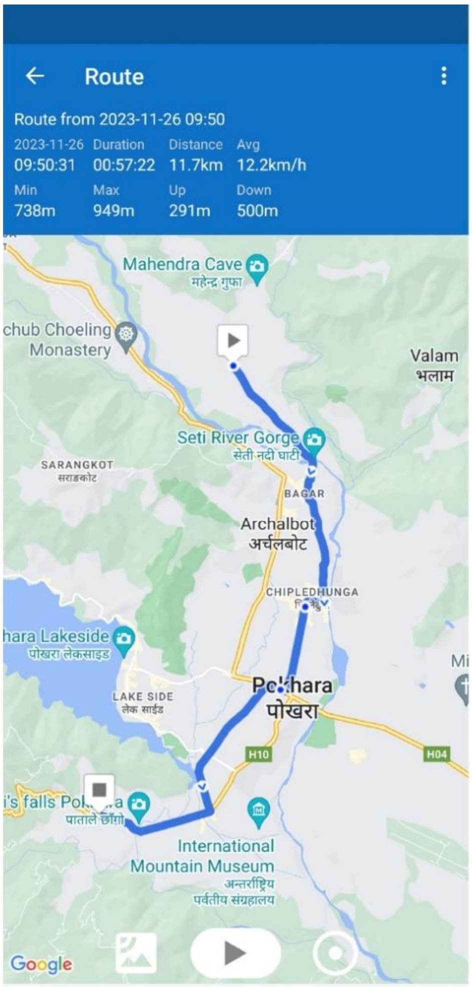


Figure 3-7: My Track App Tracking the route

3.2 Technology Implemented

3.2.1 GNSS Technology

Global Navigation Satellite System (GNSS) include constellations of Earth-orbiting satellites that broadcast their locations in space and time, of networks of ground control stations, and of receivers that calculates ground positions by trilateration. GNSS include two fully operational global systems, the United States' Global Positioning System (GPS), the Russian Federation's Global Navigation Satellite System (GLONASS), as well as the developing global and regional systems, namely Europe's Satellite Navigation System (GALILEO) and China's COMPASS/BeiDou, India's Regional Navigation Satellite System (IRNSS) and Japan's Quasi-Zenith Satellite System (QZSS). The satellite broadcasts two codes – the coarse acquisition (C/A) code, unique to the satellite, and the navigation data message.

In general GNSS provides three types of measurements: Pseudorange, carrier phase, and Doppler. By pseudoranging, the GNSS user measures an approximate distance between the GPS antenna and the satellite by correlation of a satellite transmitted code and a reference code created by the receiver. Four pseudorange observations are needed to resolve a GNSS 3-D position. In practice there are often more than four satellites within view. A minimum of four satellite ranges are needed to resolve the clock-biases contained in both the satellite and the ground-based receiver. Thus, in solving for the X-Y-Z coordinates of a point, a fourth unknown (i.e. clock bias ~Δt) must also be included in the solution. The solution of the 3-D position of a point is simply the solution of four pseudorange observation equations containing four unknowns, i.e. X, Y, Z, and Δt.

A pseudorange observation is equal to the true range from the satellite to the user plus delays due to satellite receiver clock biases and other effects.

$$R = p^t + c\,(\Delta t) + d$$

where

R = observed pseudorange

p^t = true range to satellite (unknown)

c = velocity of propagation

Δt = clock biases

d = propagation delays due to atmospheric conditions

SAM-M8Q GPS Breakout is chosen as the receiver of the GNSS signals which is responsible to accurately locate the points within the earth surface. The SAM-M8Q is a 72-channel GNSS receiver, meaning it can receive signals from the GPS, GLONASS, and Galileo constellations which increases precision and decreases lock time.

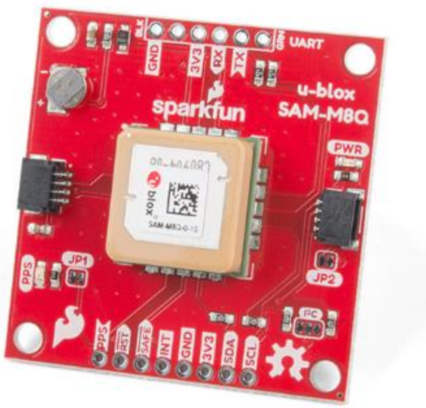


Figure 3-8: SparkFun GNSS Breakout - Chip Antenna, SAM-M8Q (Qwiic)

3.2.2 GPRS Technology

General packet radio service (GPRS) is defined as a mobile communications standard that operates on 2G and 3G cellular networks to enable moderately high-speed data transfers using packet-based technologies GPRS Working. In essence, general packet radio service (GPRS) is a packet-switching technology that makes it possible to send data over mobile networks. Multimedia messaging services, internet connectivity, and other forms of data transmission are made use of this. GPRS cell phones, laptops, and portable devices with GPRS modems can all support GPRS. Up to 80 Kbps downstream bandwidths have been reported by subscribers. The second generation (2G) cellular network uses the global system for mobile communications (GSM) as its primary standard; GPRS is an enhanced version. Unlike GSM's short messaging service (GSM-SMS), which has a 160-byte message length limit, GPRS does not allow for this. While most networks run at about 35 kbps, GPRS has a theoretical maximum speed of 115 kbps. Unofficially, GPRS is sometimes referred to as 2.5G. It's a third-generation method of becoming accessible online.

Figure 3-9: GSM/GPRS 800L Module

3.2.3 Mobile Application Development using React Native

React Native is an open-source framework developed by Facebook for building mobile applications using JavaScript and React. It enables programmers to create mobile applications that work on both the iOS and Android platforms by utilizing React, a well-liked JavaScript library for creating user interfaces. Developing cross-platform mobile apps with a single codebase is made possible by React Native, which saves time and effort when compared to developing apps specifically for each platform.

The ability to display the geospatial features found on the earth earth's surface on a mobile device is made possible by the integration of geospatial data with the mobile device. The app can display any geospatial data over a basemap, including hospital, road, house, bus station, bus route, and many other features. MapLibre is the source of the basemap used in this application. MapLibre is an open-source library for interactive maps on the web. It is a fork of the Mapbox GL JS library, which is a JavaScript library for rendering interactive maps.

Maps can be integrated into React Native applications with the help of the well-liked third-party library react-native-maps. Through the use of the MapView component, which is available for both iOS and Android, developers can incorporate interactive maps into their mobile applications. GeoJSON (Geographic JavaScript Object Notation) is an open standard format designed for representing geographical features and their attributes. It is a text-based, lightweight data interchange format that uses the JavaScript Object Notation (JSON) syntax to encode geographic data. GeoJSON is a widely used protocol that many GIS (Geographic Information System) software systems support for transferring spatial data between web servers and web clients.

3.3 Working Methodology of Device Smart Bus Tracking System (SBTS)

The core of your system lies in the device composed of ESP-32 microcontroller, SAM-M8Q GPS module, and GSM-800L module. This device is installed on each bus and serves as the primary data collection unit. The SAM-M8Q GNSS module continuously gathers the precise location data of the bus, while the GSM-800L module facilitates communication with the server. Upon detecting the bus's location, the ESP-32 microcontroller processes the data and packages it into a format suitable for transmission. Using the GSM-800L module, the device establishes a connection with the server, where a MySQL database is hosted. Through this connection, the device sends the collected location data to the server in real-time.

On the server side, the MySQL database receives the incoming data from the bus tracking devices. The database is structured to efficiently store and manage the location data, organizing it based on timestamps and other relevant parameters. This ensures that the location information is readily accessible and retrievable for subsequent analysis and display. Meanwhile, on the user end, the MeroBus Android application acts as the interface for accessing the real-time bus location data. When a user launches the app and requests to view the current location of a specific bus, the application sends an API request to the server.

In response to the API request, the server queries the MySQL database and retrieves the most recent location data corresponding to the requested bus. The retrieved data is then transmitted back to the MeroBus application, where it is processed and displayed to the user in a user-friendly format, such as on a map interface. Since the bus tracking devices upload data to the database in real-time, users can access up-to-date location information instantly through the MeroBus app. This seamless integration of hardware devices, server-side database management, and mobile application interface ensures a smooth and efficient bus tracking experience for users, enabling them to monitor bus locations and plan their journeys effectively in real-time.

Furthermore, the real-time nature of the data transmission allows for dynamic updates within the MeroBus application, ensuring users have access to the latest information on bus locations and movements. This instantaneous retrieval and display of location data empower users to make informed decisions about their travel plans, such as estimating arrival times at their desired bus stops or identifying alternative routes in case of delays. Additionally, by leveraging the capabilities of the MySQL database to store historical location data, the system can offer valuable insights into bus performance metrics over time, enabling transportation authorities to optimize routes, schedules, and service delivery. Overall, the seamless integration of hardware components, server infrastructure, and user-facing application functionality culminates in a comprehensive Smart Bus Tracking System that enhances the efficiency, transparency, and accessibility of public transportation services in Pokhara Metropolitan City.

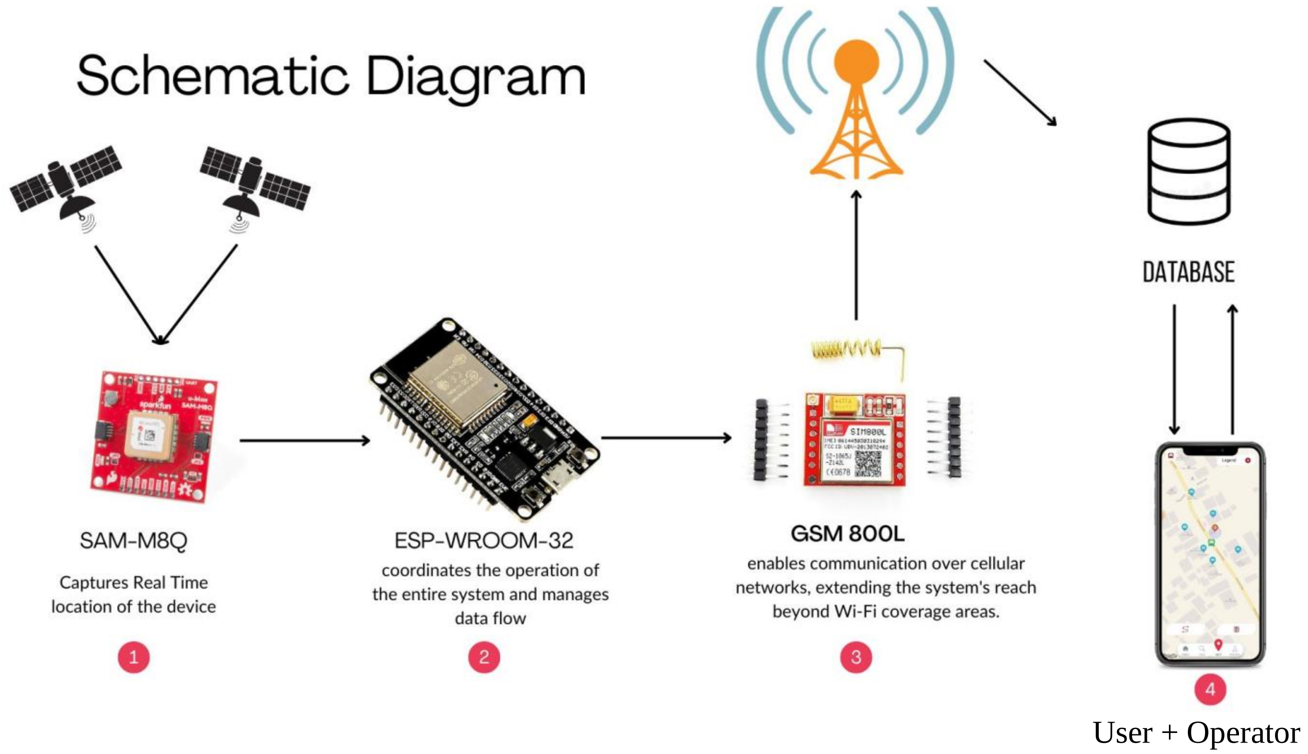


Figure 3-10: Schematic Diagram of working of SBTS

3.4 Design and Implementation of Tracking System

Our real-time tracking management system is an open system built with readily available commodity hardware and free and open source software. Our system is composed of three components, a GPS Tracking Device, a server, database and mobile application as shown in Figure 1. The device's exact location is seamlessly provided by the GPS tracking device, and a microcontroller is used to format and control it. In this system we used ESP-WROOM-32 as the microcontroller.ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. When a vehicle is located in a remote area, its position (latitude and longitude) is sent via a GSM modem. The latitude and longitude, which indicate the position of the vehicle, are continuously provided by the GPS modem. The GPS modem outputs a wide range of parameters, but only the NMEA data that is received by the device. We used SAM-M8Q, a 72-channel GNSS receiver, for GPS tracking because it can receive signals from the Galileo, GLONASS, and GPS constellations, increasing precision and reducing lock time.

3.4.1 Smart Bus Tracking System (SBTS)

In our project we have developed the device called Smart Bus Tracking System (SBTS) which is imbedded with the SparkFun SAM-M8Q GNSS receiver which is a GNSS receiver and can receive 72-channel meaning it can receive signals from the GPS, GLONASS, and Galileo constellations which increases precision and decreases lock time. The device also contain the General packet radio service (GPRS) module along with the microcontroller. In this project we have used ESP-WROOM-32 microcontroller which is really powerful. The main purpose of the microcontroller is to control the signal coming out from the SAM-M8Q GNSS receiver since the GNSS receiver receives the satellite data in NMEA format. NMEA (National Marine Electronics Association) is a standard communication protocol used by marine and terrestrial navigation systems to enable devices from different manufacturers to communicate with each other. The NMEA data format is particularly common in the context of GPS (Global Positioning System) receivers and other navigation devices. One of the example of NMEA sentences is $GNGGA which is given below.

$GNGGA 123519, 2815.42533, N, 08358.61071, E, 1, 08, 0.9, 984.4, M,-39.9, M,*47

where

GGA	Global Positioning System Fix Data
123519	Fix Time taken at 12:35:19 UTC
2815.42533,N	Latitude 28^0 15.42533’ N
08358.61071,E	Longitude $83^0$58.61071’E
1	Fix quality
08	Number of satellite being tracked
0.9	HDOP
984.4,M	Altitude, meters, above mean sea level
-39.9,M	Height of geoid(MSL) above WGS84 ellipsoid
*47	The checksum data always being with the *

Since such types of message is difficult to transmit through the SIM800L module so firstly microcontroller handle the satellite data and convert the data into transformable format. The SAM-M8Q had library which convert the NMEA message into latitude, longitude, speed, DOP, Number of satellite, elevation etc. After that this data is then format into JSON format. JSON, which stands for JavaScript Object Notation, is a lightweight data interchange format. It is easy for humans to read and write, and it is also easy for machines to parse and generate. JSON data is represented as key-value pairs in a hierarchical structure. JSON is commonly used for data exchange between a server and a web application, as well as for configuration files and other data storage purposes. Here is an example of JSON containing the location data provided by the device.


```
{
   "data": [
      {
         "id": "1319",
         "lat": "28.257350",
         "lng": "83.976493",
         "created_date": "2024-01-30 20:02:45"
      }
   ]
}
```


3.4.2 Database Preparation

It is crucial to develop a database which is used to store the data which is sent by the tracking device. The purpose of the database is to store, retrieve, review and analyse the data. After formatting, the data is then sent to the database through the GSM/GPRS 800L module which is capable of transmitting the data wirelessly. The GSM 800L is imbedded with Subscriber Identity Module (SIM) which uses the local network to transmit the data. The SIM800L GSM/GPRS module is a miniature GSM modem that can be used in a variety of IoT projects. We can use this module to do almost anything a normal cell phone can do, such as sending SMS messages, making phone calls, connecting to the Internet via GPRS, and much more.

To make an HTTP request using a GSM/GPRS module such as the GSM800L, the process involves several key steps. Initially, the module must be powered up and initialized. Subsequently, a GPRS connection is established to enable mobile data communication. The configuration for the HTTP request follows, with parameters like the server URL, port, and any necessary headers or authentication information being set. The actual HTTP request is then composed, specifying the method (e.g., GET or POST), headers, and, if applicable, a request body. The request is sent using AT commands or a module-specific communication protocol. Following the transmission, the device awaits the HTTP response from the server. Upon receipt, relevant information is extracted and processed. Optionally, the GPRS connection can be terminated or resources released. This entire sequence allows devices equipped with GSM/GPRS capabilities, like the GSM800L, to interact with web servers, making it particularly useful for applications involving data exchange with remote servers or fetching information from the internet.

Now in order to store the data we created a local server with the use of XAMPP. XAMPP, which stands for Cross-Platform, Apache, MySQL, PHP, and Perl, is a free platform that allows developers to test their code locally on their own computers. This platform provides the experience of having our own mini web server at home, compatible with both Windows (WAMP) and Linux (LAMP) environments. It is a safe space to experiment and perfect code before it goes live. With the use of GPRS/GSM 800L and XAMPP the data is then seamlessly stored in the local server database. Now in order to publically accessible the data stored in the database we generate an API.

				BusNo	id	lat	lng	created_date
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2078	28.257133	83.976803	2024-01-15 19:41:54
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2077	28.257112	83.976797	2024-01-15 19:41:46
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2076	28.257091	83.976798	2024-01-15 19:41:41
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2075	28.257116	83.976806	2024-01-15 19:41:36
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2074	28.257122	83.976815	2024-01-15 19:41:31
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2073	28.257145	83.976821	2024-01-15 19:41:25
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2072	28.257141	83.976810	2024-01-15 19:41:14
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2071	28.257143	83.976808	2024-01-15 19:41:09
☐	Edit	Copy	Delete	'Ga. 1 Kha 3950'	2070	28.257130	83.976810	2024-01-15 19:41:04

Figure 3-11: Database Preparation using MySQL

3.4.3 APIs Generation

In the MeroBus project, the implementation of an Application Programming Interface (API) plays a pivotal role in overcoming the communication barrier between the mobile app and the underlying database. As users enter their source and destination within the app, the API acts as an intermediary, facilitating seamless communication with the database to retrieve and deliver pertinent information. Specifically, when a user inputs source and destination details, the API takes these parameters and queries the database for the corresponding bus fare data. Once retrieved, the API efficiently delivers this information back to the app, enabling users to access real-time bus fare details for both the general public and students. The significance of the API lies in its ability to serve as a bridge, allowing different software components to communicate and share data. In the context of MeroBus, the API streamlines the interaction between the user interface of the app and the database housing crucial fare information. Without this intermediary layer, direct communication between the app and the database would be challenging and potentially insecure. Moreover, the API encapsulates the complexity of the database queries, presenting a simplified and standardized interface for the mobile app to request and receive information. This abstraction not only enhances security but also promotes modular design, facilitating future updates or modifications to the database structure without directly impacting the app's functionality.

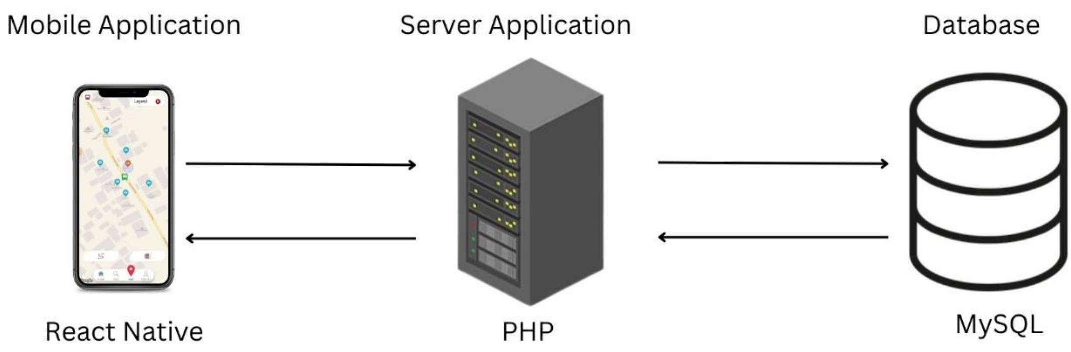


Figure 3-12: APIs Development for Mero Bus

In essence, the API serves as a facilitator for data exchange, ensuring the seamless retrieval of bus fare details for users. Its role in our project is paramount, contributing to the overall effectiveness of MeroBus by providing users with accurate and timely fare information, thereby enhancing their ability to plan and optimize their commutes in the Pokhara Valley.

So the device continuously update the latest location data with the database using GPRS/GSM 800L module and the API that is generated is used to interact with the database and the mobile application. The volume of data in the database is excessive because it is seamlessly uploaded to the server four times every second. We employed Structured Query Language (SQL) to solve this issue. We first sorted the data by ID so that the most recent information always appears at the top of the table, then we deleted every table except the last 10 locations, which remained in the database. In order for the SQL code to only keep the most recent 10 data when the application calls an API, it must first provide the most recent position data before deleting all other data.

So when the API is called,

http://My_Device_IP_address/gnss/test_data.php?action=retrieve

Then the SQL coded inside the test_data.php assign the current location using this code,

```
retrieveSql = "SELECT * FROM realtime ORDER BY id DESC LIMIT 1";
```

Subsequently, an additional SQL query is executed, eliminating all the data except for the most recent 10 position data.

```
deleteSql = "DELETE FROM realtime WHERE id < (SELECT id FROM realtime ORDER BY id DESC LIMIT 1 OFFSET 9)";
```

This is done in order to insure that the storage of the database is not full and eventually stops running. We can also store the data all the day if needed for the analysis. In addition to real-time bus tracking, our application boasts a convenient bus fare calculator feature. This functionality simplifies the process of determining bus fares between individual stations for users. When a user inputs their source and destination within the app, it leverages data provided by Pokhara Transportation Pvt. Ltd. to calculate the bus fare, considering both regular and discounted rates for students and public users. By integrating this feature, our application enhances the overall user experience by providing instant access to fare information, enabling commuters to budget and plan their journeys more effectively.

To facilitate fare calculation, our application utilizes a Rest API to fetch the necessary data stored in the database. When a user inputs their source and destination, the application triggers a request to the Rest API. This API serves as the intermediary between the mobile device and the database, enabling seamless communication and data retrieval. Upon receiving the request, the Rest API queries the database for the relevant fare information based on the user-provided source and destination. Once the data is retrieved from the database, the Rest API sends it back to the mobile device, where it is displayed to the user. This streamlined process ensures that users receive accurate and up-to-date fare information directly on their mobile devices, enhancing the convenience and efficiency of their journey planning experience.

So when the API is called,

http://My_Device_IP_address/gnss/busFare.php?compute=calculate&source=lamachaur&destination=bagar

Then the SQL coded inside the busFare.php assign the latest bus fare using this code,

```
if ($_SERVER['REQUEST_METHOD'] === 'GET' && isset($_GET["compute"]) &&
$_GET["compute"] == "calculate" && isset($_GET["source"]) &&
isset($_GET["destination"])) {

    $source = mysqli_real_escape_string($conn, $_GET["source"]);

    $destination = mysqli_real_escape_string($conn,
$_GET["destination"]);



    $retrieveFairSql = "SELECT * FROM busfare WHERE source = '$source' AND
destination = '$destination'";

    $resultFair = mysqli_query($conn, $retrieveFairSql);

    if ($resultFair) {

        $data = array();

        while ($row = mysqli_fetch_assoc($resultFair)) {
            $data[] = $row;

        }

        // Output the result in JSON format

        echo json_encode($data);

    } else {

        echo json_encode(array("error" => "Error retrieving data: " .
mysqli_error($conn)));

    }

} else {

    // Handle invalid or missing parameters

    echo json_encode(array("error" => "Invalid request"));

}
```

The response of the API request is structured in JSON format for ease of retrieval and processing by the application. This JSON response contains the relevant fare information based on the user's requested source and destination. By adhering to the JSON format, the application can efficiently parse the response and extract the necessary fare data to present to the user. This standardized format ensures compatibility and seamless integration between the Rest API and the mobile application, enabling smooth communication and accurate fare calculation. With the fare information neatly organized in JSON format, users can quickly access and view the bus fare for their desired route within the application, enhancing their overall travel planning experience.


```
[
  {
    "id": "2",
    "source": "lamachaur",
    "destination": "bagar",
    "student": "15",
    "publicfare": "25",
    "date": "2024-04-26 21:15:08"
  }
]
```

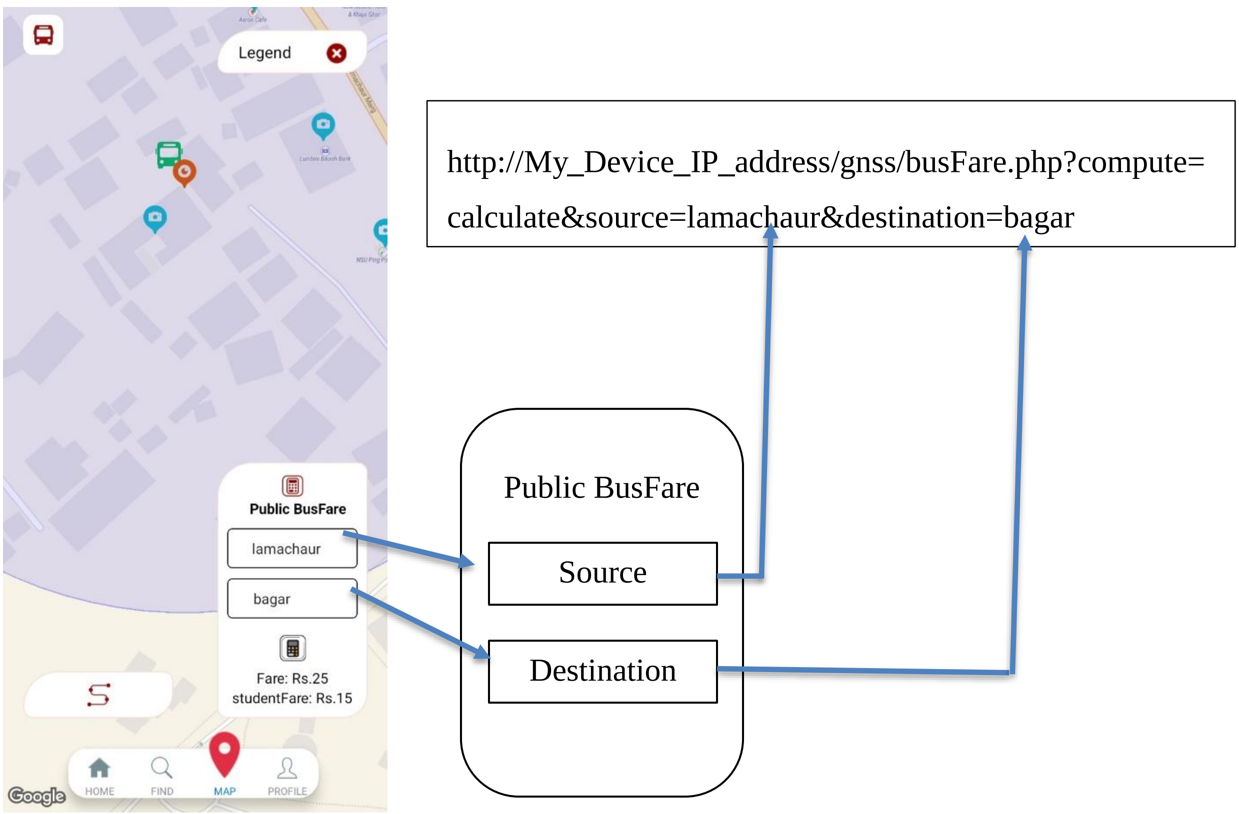



Figure 3-13: Schematic Diagram of how Bus Fare API Works

3.5 HARDWARE DESIGN

In order to achieve the real time tracking of the public bus we have developed a prototype Smart Bus Tracking Device (SBTD). This device is imbedded with SAM-M8Q which receives GNSS signal and gives the precise location of the point. Another device that is attached with this is GPRS/GSM 800L module which is capable not only for messaging and phone calls but it is also capable to do http request to the server. With the help of the cellular network and a SIM card inserted into the device it can communicate with the server and do http request which helps to send the position data through internet and store the position data into the database. Let’s breakdown the structure into the two parts-connection between the SAM-M8Q and the ESP-WROOM-32 and the connection between the GPRS/GSM 800L module with the ESP-WROOM-32.

3.5.1 Connection between SAM-M8Q and ESP-WROOM-32

The SAM-M8Q module, produced by u-blox, is a Global Navigation Satellite System (GNSS) receiver commonly integrated into various applications requiring accurate positioning and navigation. The module operates within a specified voltage range, usually around 2.7V to 3.6V, and is designed for low power consumption, making it suitable for battery-powered applications. The SAM-M8Q typically communicates with a microcontroller or a host system using an I2C communication. I2C is a two-wire serial communication protocol using a serial data line (SDA) and a serial clock line (SCL). The protocol supports multiple target devices on a communication bus and can also support multiple controllers that send and receive commands and data. This allows the module to send and receive commands and data from the host system.

In order to check and verify the I2C connection we have used Arduino IDE software. The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. In order to check the connection, inside the Arduino IDE software,

```
#include <Wire.h>
void setup() {
  Wire.begin();
  Serial.begin(9600);
}
```

```
void loop() {
  // Request data from SAM-M8Q
  Wire.beginTransmission(SAM_M8Q_I2C_ADDRESS);
  Wire.write(REGISTER_TO_READ);
  Wire.endTransmission();
   // Read data from SAM-M8Q
  Wire.requestFrom(SAM_M8Q_I2C_ADDRESS, NUM_BYTES_TO_READ);
  while (Wire.available()) {
    int data = Wire.read();
    // Process the data as needed
  }
  delay(1000); // Adjust as needed based on the SAM-M8Q update rate
}
```

The architecture of the connection between the SAM-M8Q and the ESP-WROOM-32 is shown below.

Table 3-2: Connection Guide between SAM-M8Q and ESP-WROOM-32

Sparkfun SAM-M8Q	ESP-WROOM-32
3V3	3V3
GND	GND
SDA	D21
SCL	D22

The connection diagram between the devices is shown below. In order to continuously operate the microcontroller, we have to supply a power supply of 5 volts. Since the battery we have is 7.4V, we have to first drop the voltage to 5V before we can send it to the microcontroller. For this, we have used a voltage drop-down regulator connected to the capacitor. The voltage regulator is essential for stabilizing the output voltage when lowering the voltage from 7.4V to 5V to power an ESP32 microcontroller. Since the ESP32 normally needs a certain voltage to function properly, this conversion is essential. Furthermore, a capacitor is frequently added at the regulator's output to improve stability by decreasing noise and smoothing out voltage fluctuations. By assisting as a buffer, the capacitor reduces the impact of abrupt changes in current demand and promotes a more steady DC output. The ESP32 is then given the filtered and regulated 5V output, which satisfies its power needs.

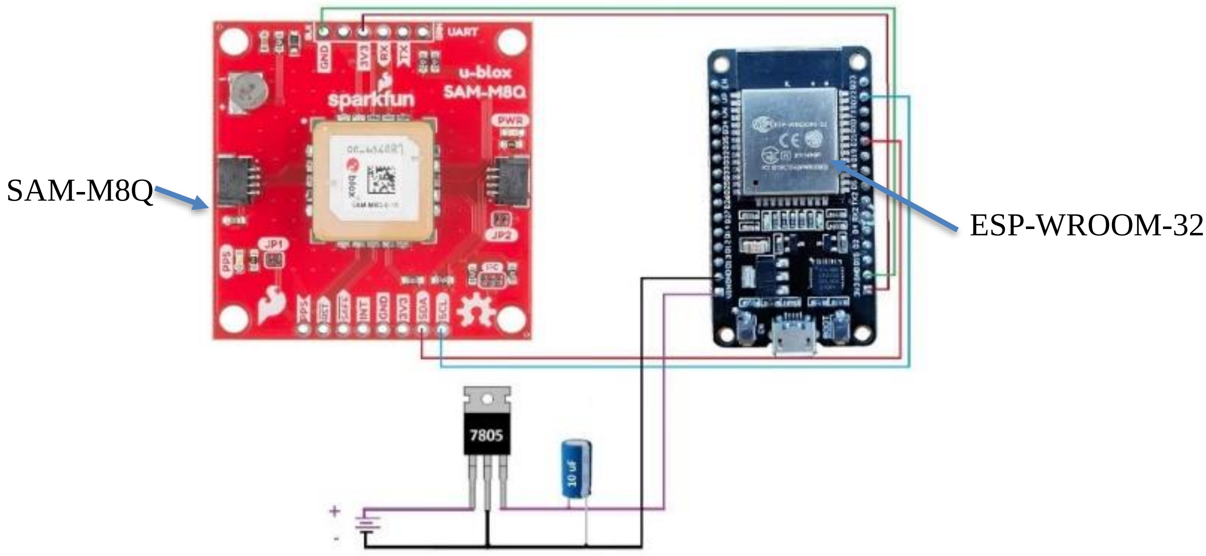


Figure 3-14: Schematic Diagram between GPS receiver and ESP-32

3.6 Connection between GPRS/GSM 800L with microcontroller

Typically, serial communication using the UART (Universal Asynchronous Receiver-Transmitter) communication protocol is required to connect an ESP32 to a GSM module such as the SIM800L. The link between an ESP32 and the GSM SIM800L module is broken down as follows:

3.6.1 Hardware connections

Connect the TX (Transmit) pin of the SIM800L module to the RX (Receive) pin of the ESP32, and vice versa. Because the SIM800L module lacks an on-board voltage regulator, we must select a power supply capable of supplying the SIM800L module within its 3.4V to 4.4V range (preferably 4.0V). Also the power supply must be capable of supplying at least 2A of surge current; otherwise, the chip will repeatedly reset. We use a 2A-rated DC-DC buck converter, such as the LM2596, with the output voltage set to 3.5V. These are far superior to linear voltage regulator modules in terms of efficiency.

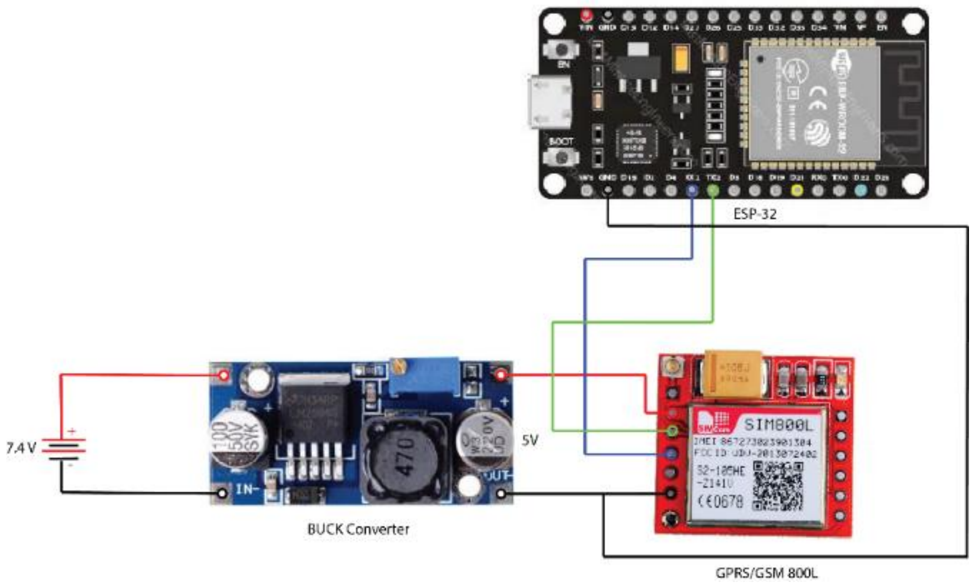


Figure 3-15: Schematic Diagram between GPRS/GSM and ESP-32

3.6.2 Serial Communication Configuration

In the ESP32 firmware code, configure the serial communication for the UART interface. We use the Arduino IDE and the SoftwareSerial library.

```
#include <SoftwareSerial.h>
SoftwareSerial gsmSerial(RX_PIN, TX_PIN); // Define SoftwareSerial object
void setup() {
   Serial.begin(115200); // Initialize serial for debugging
   gsmSerial.begin(9600); // Initialize GSM module serial communication
}
void loop() {
   // Your GSM communication code here }
```

3.6.3 AT Commands

Conventionally, AT commands are used to communicate with the GSM module. We use the established serial connection to transmit AT commands from the ESP32 to the SIM800L module. The GSM module can be used to send SMS, make calls, and manage network-related tasks thanks to AT commands.

```
void sendATCommand(String command) {
   gsmSerial.println(command);
   delay(500);
```

```
}
void setup() {
    // Initialization code
    sendATCommand("AT"); // Example AT command
}
void loop() {// Your main code}
```

The overall schematic diagram of the device is shown below.

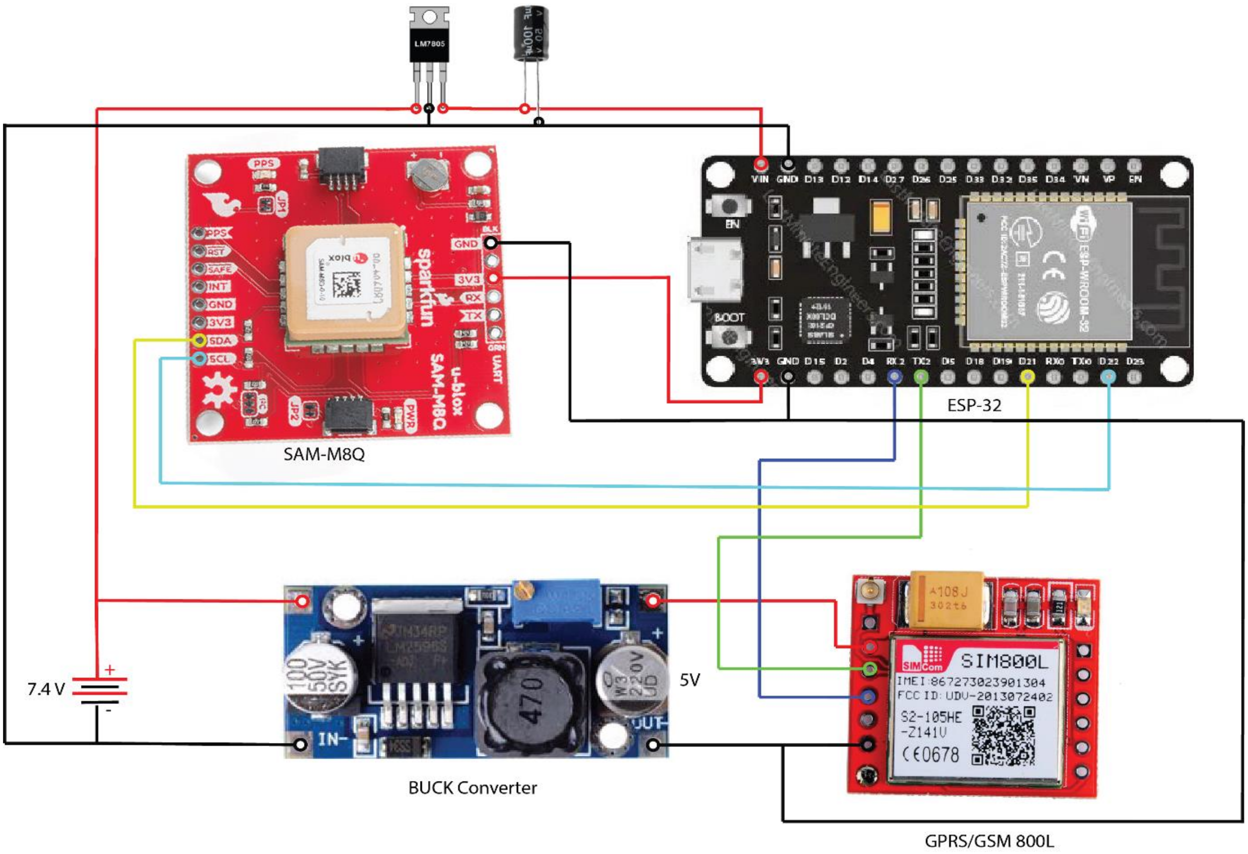


Figure 3-16: Schematic Diagram of Smart Bus Tracking System (SBTC)

CHAPTER 4 RESULT AND DISCUSSION

Improving the effectiveness and user experience of the Pokhara Metropolitan City bus tracking system is the main goal of our project. The Android application seeks to give users up-to-date information about bus locations by integrating crucial features like precise bus numbers, accurate timings, and GPS tracking for accurate location. By enabling users to arrange their itineraries, calculate travel durations, and retrieve fare information, this feature ultimately decreases wait times and boosts user satisfaction. The addition of these features improves the efficiency and productivity of the public transportation system in addition to streamlining it. In the future, there exist ample opportunities for improvements that could further increase the usefulness of our project. A potential future direction is the development of an all-encompassing car monitoring system that makes use of GPS modules that are equipped with fast processors. The scope and impact of our project could be expanded by incorporating different forms of transportation, such as cars, jeeps, and taxis, into this system in addition to buses. In keeping with the overall strategy, we can also investigate incorporating a bus ticketing system into the application. This feature, which includes location-based fare calculations and convenient payment options through third-party applications like Eswea and Khalti, could make digital ticket purchases easier.

4.1 Analysing the Pokhara Bus System: Findings from Survey Information

The analysis of survey data on Pokhara's bus system reveals several significant findings. Firstly, there is a notable high frequency of bus usage, particularly among students, indicating a heavy reliance on public transportation for commuting purposes. Additionally, the survey indicates that cash remains the predominant mode of payment for bus fares, highlighting the importance of maintaining accessibility to cash transactions for commuters. In terms of affordability, feedback varies, but overall suggests that bus fares are moderately affordable for the majority of users. The survey also indicates that waiting times during peak hours typically range from less than 10 minutes to around 20 minutes, indicating a reasonable frequency of buses serving the routes. However, a notable issue identified is the lack of accessibility to accurate bus schedule and route information. Users primarily rely on word of mouth and social media for such information, indicating a need for improved dissemination of accurate and up-to-date information regarding bus schedules and routes to enhance the overall commuting experience.

The survey findings reveal mixed perceptions regarding the convenience, seating availability, cleanliness and maintenance of buses in Pokhara. While some respondents express satisfaction with these aspects, others highlight areas for improvement, indicating the need for enhanced comfort and upkeep standards on buses. Punctuality ratings vary among respondents, suggesting inconsistencies in adherence to schedules by bus operators. Similarly, feedback on the behaviour and professionalism of bus drivers and conductors is mixed, highlighting the importance of ongoing training and standards enforcement in the transportation sector.

Better capacity management techniques are required when overcrowding becomes a major issue on particular routes and times, especially in the evenings and during business hours. Furthermore, a noteworthy amount of support for electric or environmentally friendly buses is expressed by respondents, indicating a growing interest in and awareness of sustainable transportation options. Furthermore, there is a strong demand for real-time tracking systems and mobile apps for scheduling among respondents, indicating a desire for improved accessibility and convenience in public transportation services. Integration of Wi-Fi or internet connectivity on buses is also considered important for enhancing the overall travel experience, suggesting potential areas for future investment and innovation in Pokhara's public transportation infrastructure.

4.2 Use of Public Transportation system in Pokhara

Out of the total respondents, approximately 63% or 158 individuals answered "yes," indicating that they use the public transportation system in Pokhara which is shown in Figure 4-1. Conversely, approximately 37% or 92 respondents answered "no," indicating that they do not use it. The aforementioned data highlights the interesting involvement of a considerable segment of the population under survey with the Pokhara public transport system. It emphasizes how crucial it is to understand and respond to users' needs and preferences in order to improve the accessibility, effectiveness, and general quality of Pokhara's public transportation system.

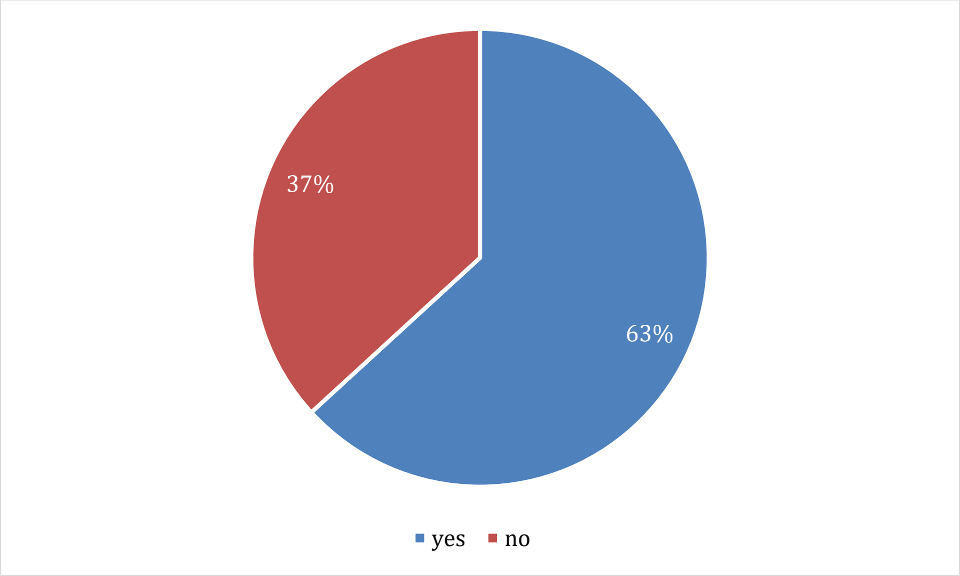


Figure 4-1: Use of Public Vehicle in Pokhara as of Field Survey

4.3 Waiting Time for Bus

The survey data on waiting times for buses reveals the following distribution among respondents:

- Less than 10 minutes: This category comprises 53% of the respondents. Individuals in this group typically wait for the bus for a short duration, suggesting that buses in their area arrive relatively quickly, enhancing the overall convenience of public transportation.

- 10 to 20 minutes: Approximately 41% of the respondents fall into this category. They wait a bit longer than the first group but still within a reasonable timeframe, indicating moderate bus frequency and satisfactory service levels for the majority of users.

- More than 20 minutes: Only 6% of the respondents reported waiting for the bus for more than 20 minutes which is shown in Figure 4-2. This smaller proportion of people experience longer waiting times, possibly due to less frequent bus schedules or other factors affecting bus service reliability. Identifying and addressing the underlying reasons for longer wait times can help improve the overall efficiency and accessibility of public transportation services for all users.

In summary, the survey findings indicate that the majority of respondents experience relatively short wait times for buses, with a smaller percentage facing longer waiting periods. This suggests that, overall, public transportation services in the area provide reasonably prompt and convenient access to buses for most passengers.

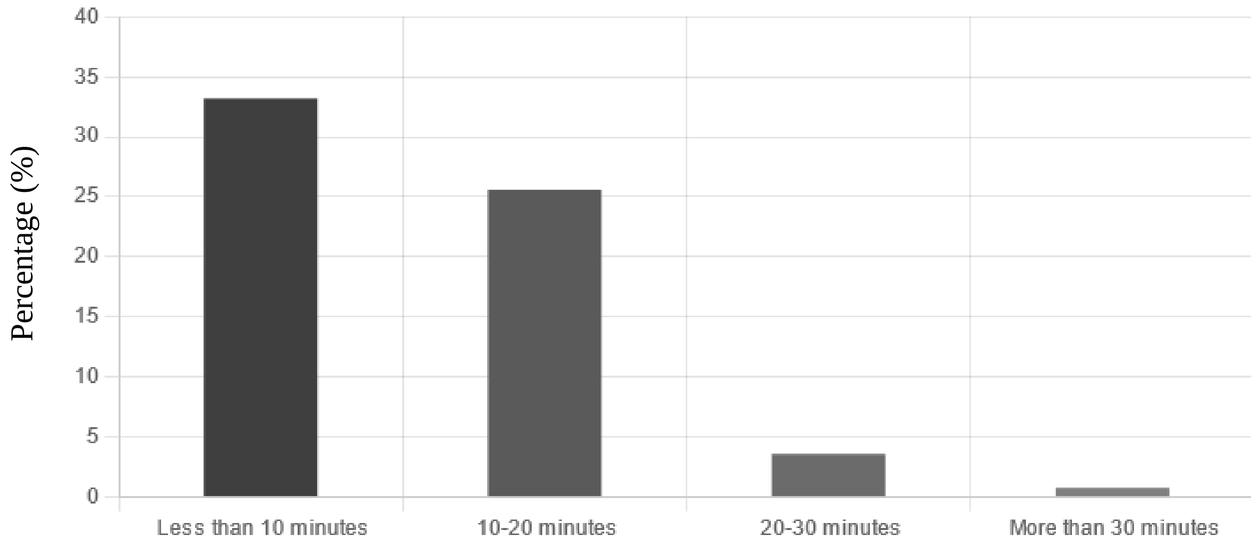


Figure 4-2: Waiting Time for Bus as of Field Survey

4.4 Scale of Affordability

The survey results regarding the affordability of the item or service reveal the following distribution among respondents:

- Scale 1 (Expensive): Only 2% of participants found the item or service to be expensive.
- Scale 2: Approximately 8% of participants likely perceived the item or service as moderately expensive.
- Scale 3: The majority, comprising 76% of participants, considered the item or service to be reasonably affordable.
- Scale 4: Around 10% of participants likely viewed the item or service as moderately cheap.
- Scale 5 (Cheap): Only 3% of participants found the item or service to be cheap.

These findings suggest that a significant majority of participants perceive the item or service to be reasonably affordable, with only a small percentage expressing concerns about its affordability which is shown in Figure 4-3 .

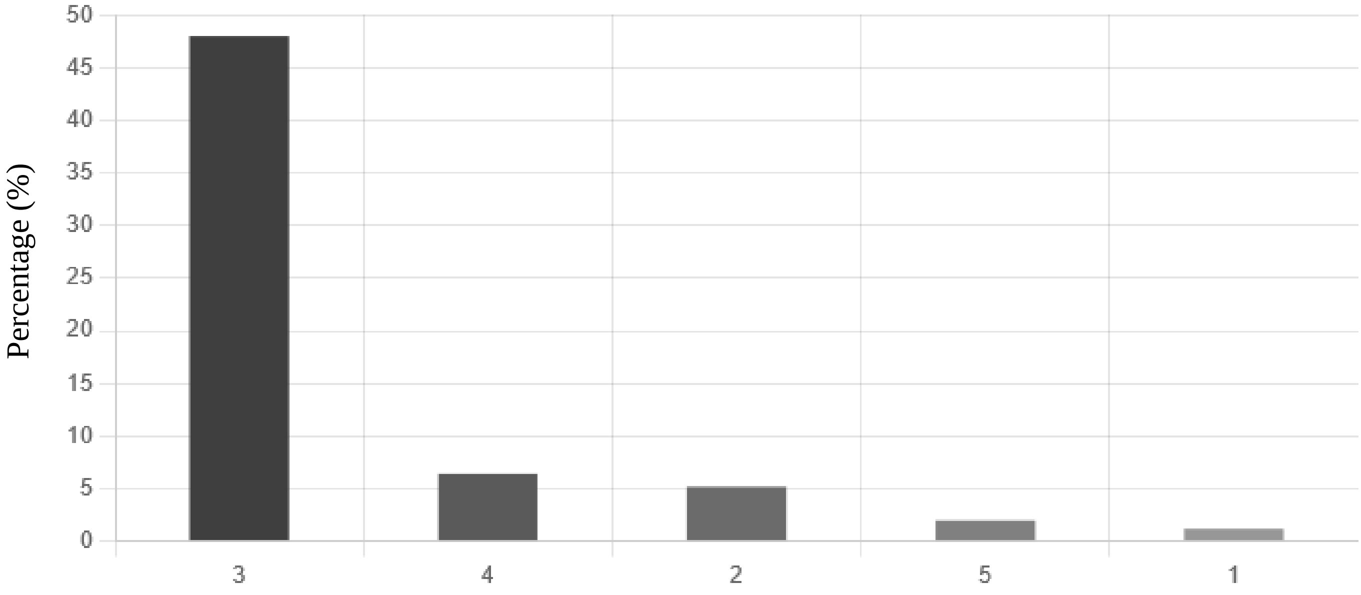


Figure 4-3: Scale of Affordability on Bus fare as of Field Survey

4.5 Respondents to the question on future use of public vehicles after improvements

Regarding the question of whether respondents would use public vehicles in the future if improvements were made, the responses were as follows:

15% of respondents indicated that they would not use public vehicles in the future, expressing satisfaction with their own vehicles.

25% of respondents stated that they would use public vehicles in the future if improvements were made. The majority, comprising 60% of respondents, expressed uncertainty, stating that their decision would depend on the extent of improvements made to the public transportation system.

These findings indicate a diverse range of perspectives among respondents, with a significant portion expressing openness to using public vehicles in the future contingent on improvements to the transportation system.

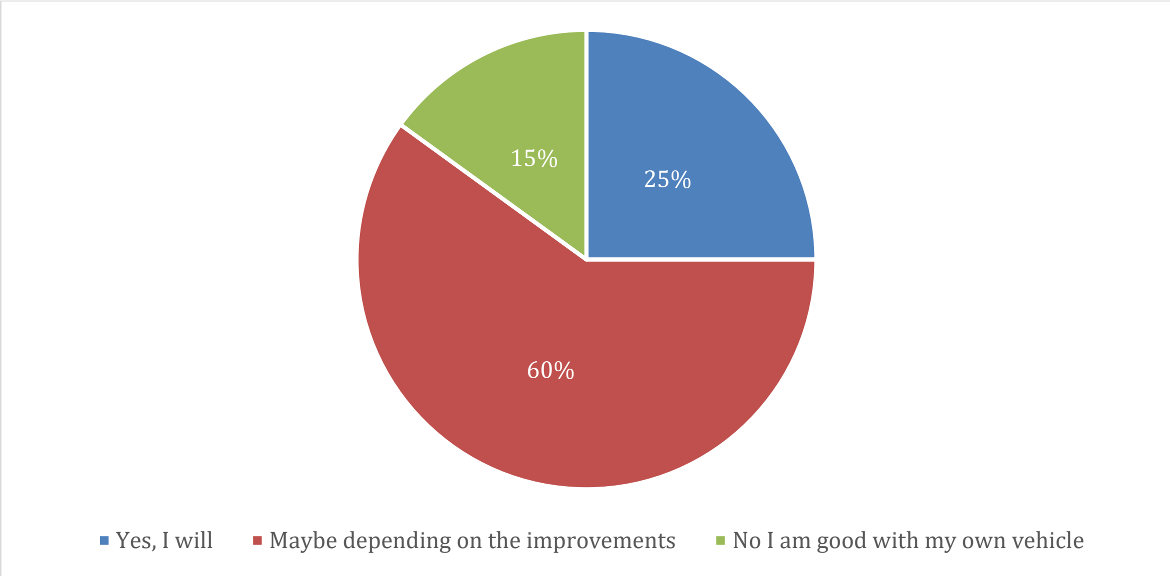


Figure 4-4: Opinion of the respondents to the question on future use of public vehicles after improvements

4.6 Age Group using Public Vehicle

The following results provide insight into the distribution of public bus usage among different age groups, with the majority of participants falling within the 25-30 age range, followed by the 20-25 age group which is shown in Figure 4-5.

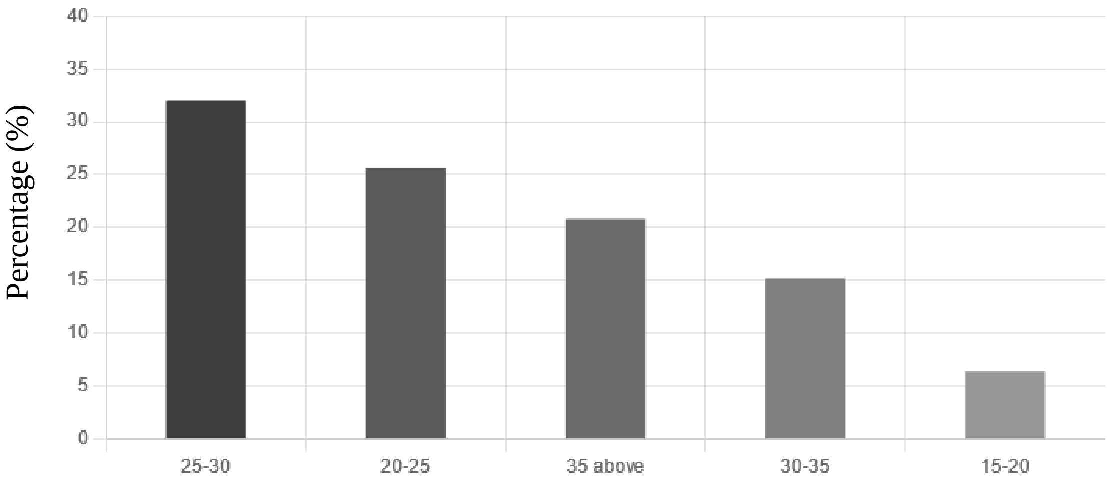


Figure 4-5: Age Group using Public Vehicle as of Survey

Here is the table showing the distribution of public bus usage among different age groups which is shown in Table 4-1. This table illustrates the distribution of public bus usage among various age groups based on the frequency of participants and the corresponding percentages.

Table 4-1: Table showing the age group using the Public Vehicle

Age Group	No of Participant	Percentage
25-30	80	32
20-25	64	25.6
35 above	52	20.8
30-35	38	15.2
15-20	16	6.4

4.7 Occupation of the Participant who Uses Public Vehicle

Among the participants surveyed, students comprise the largest demographic, indicating the widespread appeal of buses among the student population due to factors such as affordability and accessibility. Additionally, professionals from various fields, such as teachers and government officers, utilize public buses, highlighting the importance of reliable transit options for individuals across different occupations.

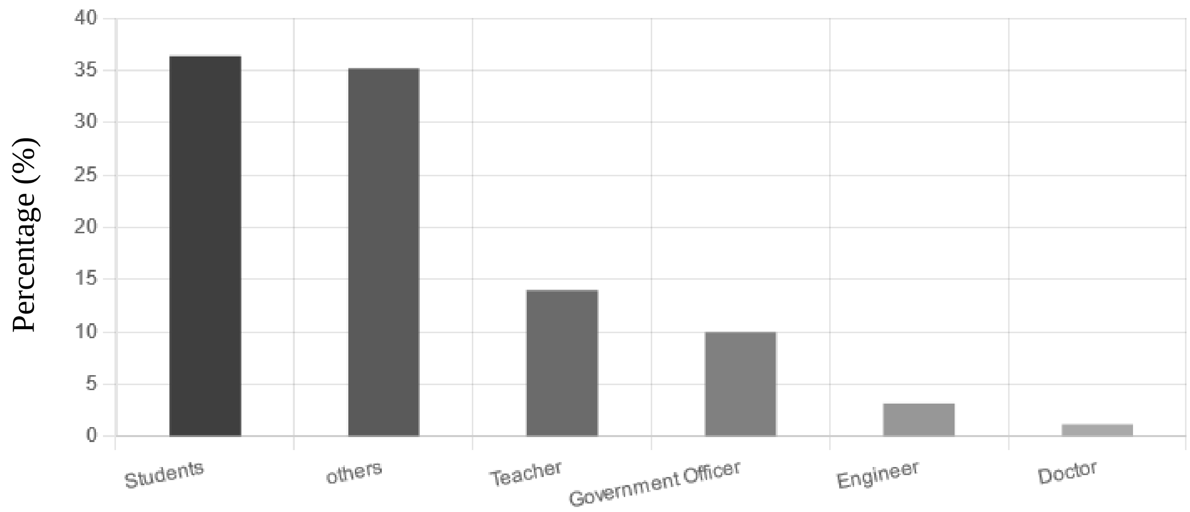


Figure 4-6: Occupation of Participant using Public Vehicle as of Survey

Even individuals with specialized professions, such as engineers and doctors, are represented among public transportation users, demonstrating the diverse range of personalities relying on buses for their daily commute as shown in Figure 4-6. Overall, the data underscores the significance of public transportation in catering to the mobility needs of a broad spectrum of personalities within the community.Here is the table showing the occupation of the participant using public which is shown in Table 4-2.

Table 4-2: Occupation of the Participant who Use Public Vehicle

Value	No of Participant	Percentage
Students	91	36.4
others	88	35.2
Teacher	35	14
Government Officer	25	10
Engineer	8	3.2
Doctor	3	1.2

4.8 Rate the punctuality of buses

The survey findings highlight the varying perceptions of bus punctuality among commuters in the Pokhara Valley.

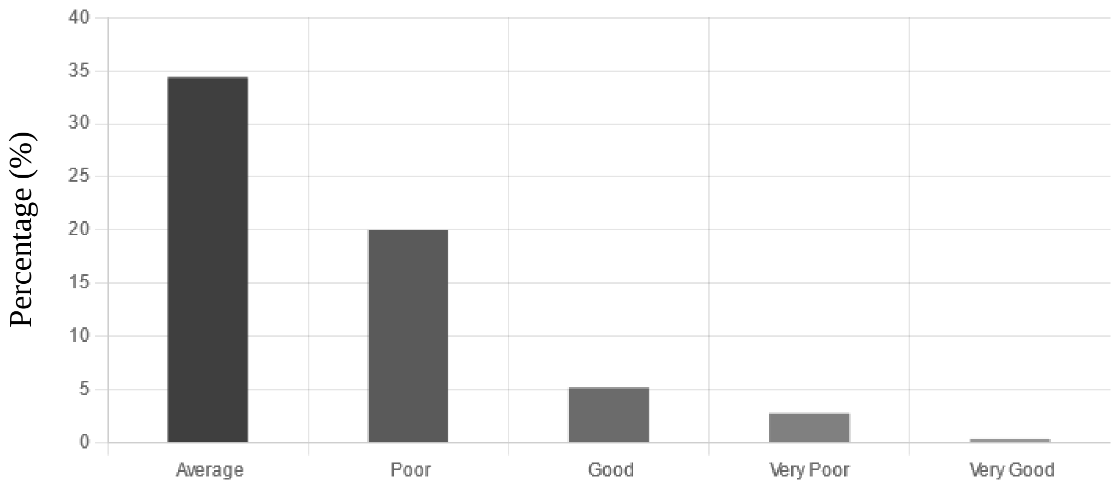


Figure 4-7: Rate of Punctuality of Bus as of Field Survey

While some individuals view buses as reasonably punctual, others express dissatisfaction with frequent delays and inconsistencies in service as shown in Figure 4-7. These insights can inform efforts to improve the reliability and timeliness of bus services to better meet the needs and expectations of commuters in the region.

Below is the table showing the rate of punctuality of the bus that are operating in the Pokhara valley as shown in Table 4-3.

Table 4-3: Punctuality of the Public Bus in Pokhara Valley

Value	No of Participant	Percentage
Average	86	34.4
Poor	50	20
Good	13	5.2
Very Poor	7	2.8
Very Good	1	0.4

Overall satisfaction with the bus system in Pokhara exhibits variability among respondents, yet there is a notable inclination to recommend it to others. Despite this positive sentiment, a significant portion of respondents still express a preference for private transportation. The main reasons for this preference are the claimed weaknesses in the public transportation system, which include issues with convenience, dependability, and safety. These findings highlight the necessity of focused enhancements to address major problem areas and improve the user experience as a whole.

To effectively enhance satisfaction levels and encourage greater use of the public bus system, transportation authorities in Pokhara should focus on implementing measures to improve convenience, reliability, and safety. This may involve initiatives such as deploying real-time tracking systems for buses, optimizing routes and schedules to reduce wait times and enhancing safety protocols and infrastructure. By prioritizing these improvements, Pokhara's bus system can become a more attractive and viable option for commuters, ultimately contributing to a more sustainable and efficient urban transportation network in the city.

4.9 Bus Fare Map in Lamachaur-Chhorepatan Route

In the visual representation of the bus fare route from Lamachaur to Chhorepatan in the Pokhara Valley, the central point of reference is Prithvichowk, serving as the hub for this transportation corridor. The map adeptly symbolizes bus fares by utilizing a strategic color-coded system.

The varying hues on the map provide an intuitive visual guide, with each color corresponding to specific fare ranges or categories. This approach enhances the accessibility of fare information, enabling users to quickly discern the cost implications associated with different segments of the route. The choice of Prithvichowk as the central point not only anchors the route geographically but also facilitates a clear understanding of fare differentials radiating from this pivotal location. This visual representation contributes to a more user-friendly experience, aiding commuters in making informed decisions about their travel expenses along the Lamachaur to Chhorepatan route in the Pokhara Valley.

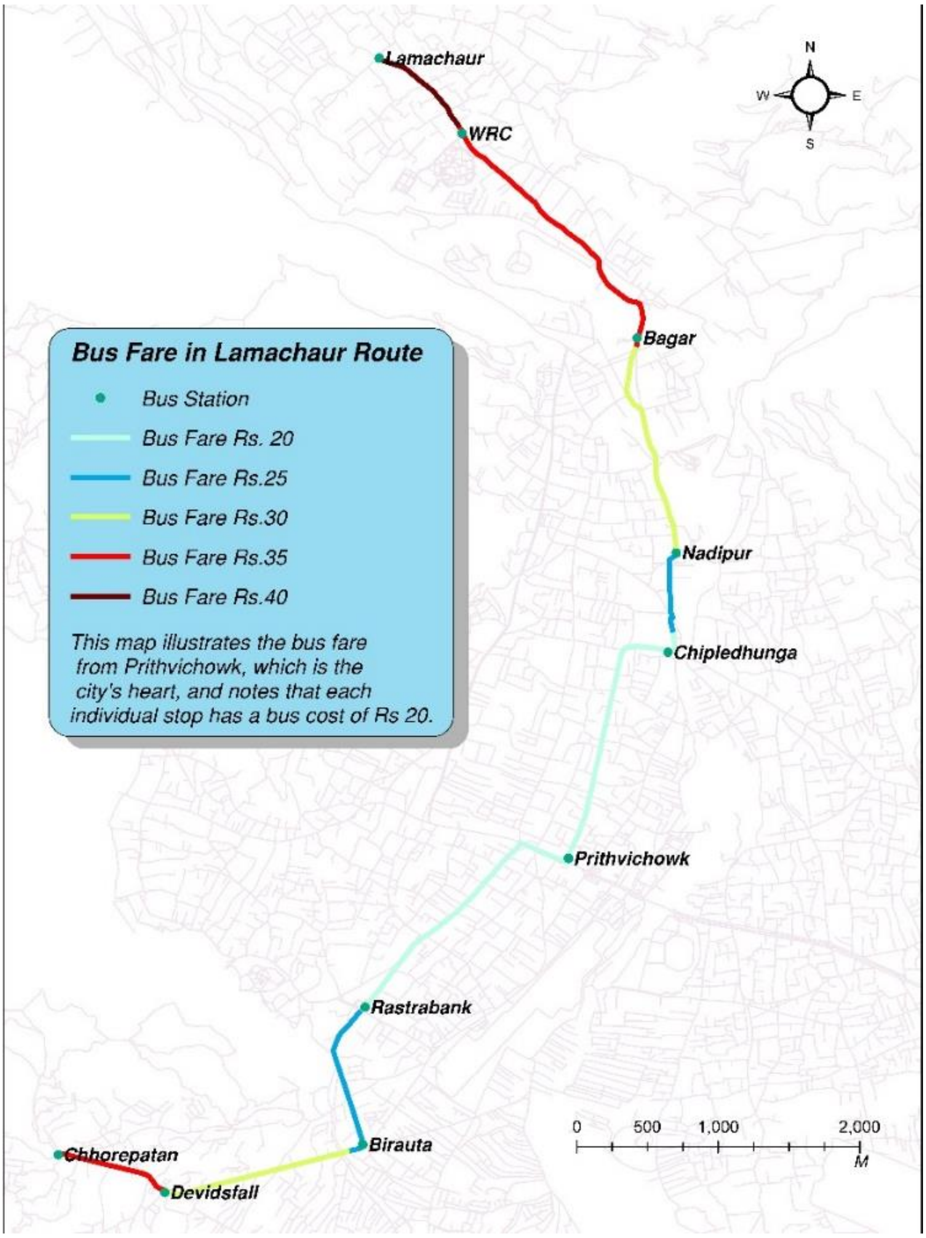


Figure 4-8: Map showing Bus Route from Lamachaur-Chhorepatan showing Bus fare Diversity

Regardless of the distance between individual stations, the fare between two adjacent stations is fixed at 20 rupees. As passengers travel to subsequent stations along the route, the fare increases by 5 rupees for each additional station. This straightforward fare structure ensures clarity and predictability for commuters, simplifying the process of calculating and understanding bus fares for travel along this route.

For students in Pokhara, a separate bus fare rule applies which is shown in Table 4-4, providing discounted rates for their travel. This discounted fare scheme aims to make public transportation more affordable for students, ensuring that they can access transportation services at a reduced cost while commuting within the Pokhara Valley.

Table 4-4: Bus fare Rate for Normal Users and Students

Bus fare for Normal User	Bus Fare for Students
20	10
25	15
30	15
35	20
40	20
45	25
50	25
55	30
60	30

4.10 Android based Mobile App Development

In the current demo phase of the MeroBus mobile app, significant strides have been made towards enhancing the user experience and functionality of public transportation in the Pokhara Valley. The integration of a Low-Cost High-Accuracy GNSS Receiver System based on QZSS MADOCA Signal is underway, representing a pivotal advancement that will bring real-time bus location tracking to the fingertips of users. The app presently displays the user's current location and provides a comprehensive overview of the entire bus route network within the

Pokhara Valley, setting the stage for a more informed and efficient commuting experience.The upcoming integration of the GNSS Receiver System signifies a critical milestone for MeroBus, as it will enable users to track the real-time location of buses operating in the valley. This functionality aligns with the app's overarching goal of offering users dynamic and accurate information to optimize their travel plans. Moreover, the API integration within the app, allowing users to access detailed bus fare information between any two stations on a specific route, is a testament to MeroBus commitment to transparency and user convenience. The inclusion of fare details for students further underscores the app's dedication to catering to diverse user demographics. As MeroBus progresses from its demo phase, these features collectively contribute to creating a robust and user-centric platform that has the potential to significantly improve the public transportation landscape in Pokhara Valley.

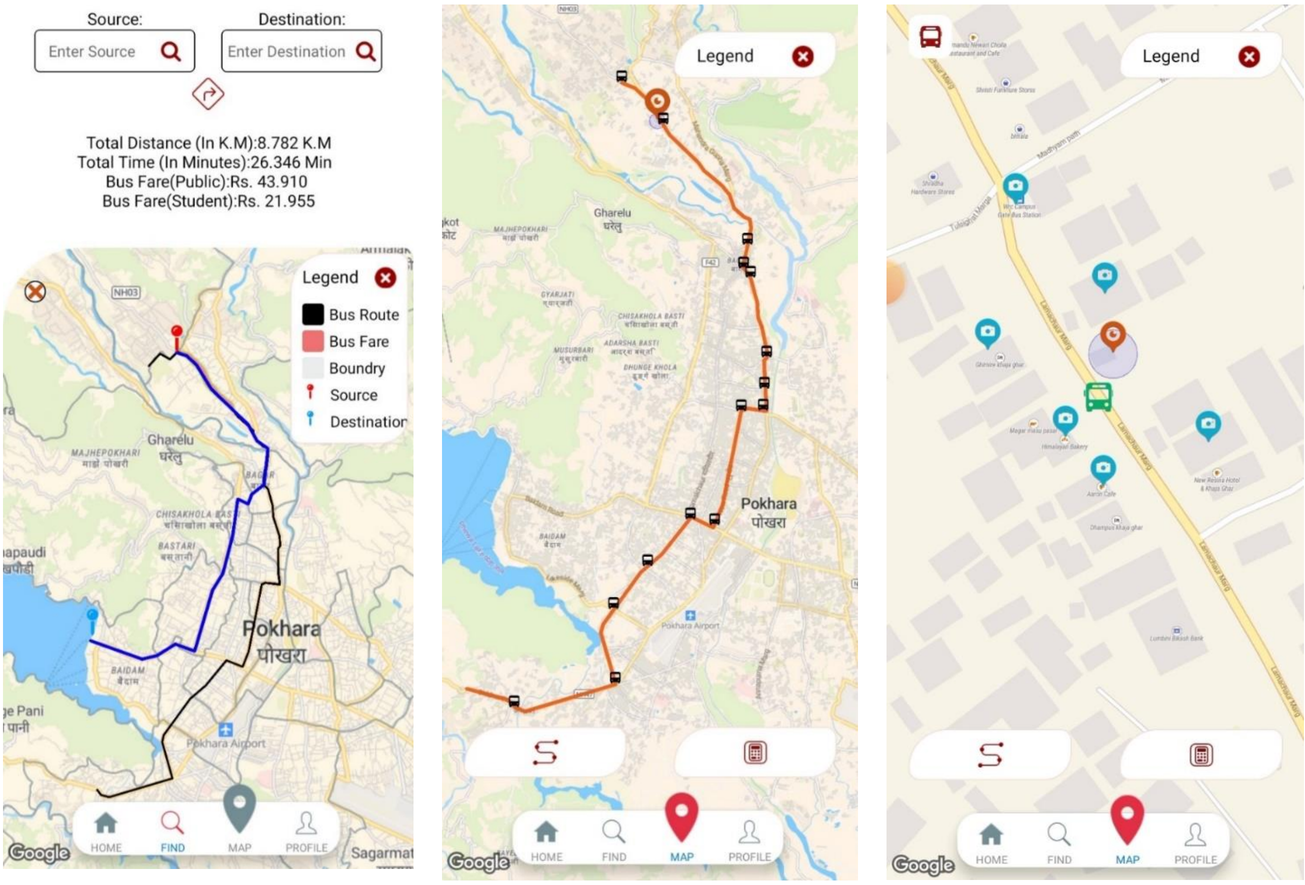


Figure 4-9: MeroBus Android Application

4.11 Smart Bus Tracking System (SBTS)

In the beautiful Pokhara Valley of Nepal, the Smart Bus Tracking System (SBTS) is a full of features and advanced tool for tracking public buses in real time. The SAM-M8Q GNSS receiver for precise positioning, a buck converter for effective voltage regulation, a GPRS/GSM module for smooth communication, and a dedicated battery for continuous power supply are all integrated into this advanced system. Real-time monitoring of bus movements by passengers and transit authorities is made possible by the precise location tracking provided by the SAM-M8Q GNSS receiver. By optimizing the power supply, the buck converter increases energy efficiency and increases the device's useful life. Continuous communication is made possible by the GPRS/GSM module, which also allows the device to send bus location data to a central server. The integration of a reliable battery ensures continuous functionality, especially in areas with intermittent power supply. The Smart Bus Tracking System thus represents a robust and efficient solution for enhancing public transportation management, providing stakeholders with valuable insights into bus movements for improved service planning and passenger experience in the Pokhara Valley.

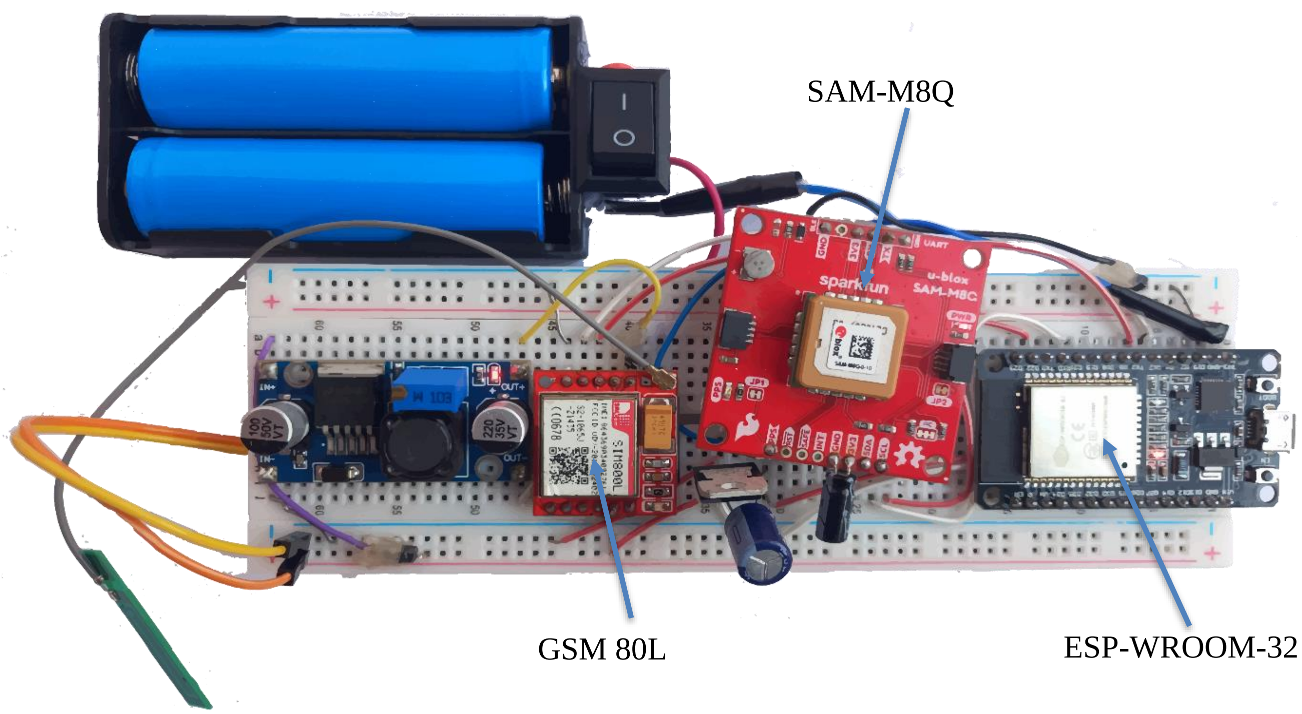


Figure 4-10: Physical Device for Public Bus Tracking (Tracking Device)

4.12 Bus fare Package System

This system allows users to purchase for monthly or weekly packages for public bus travel within Pokhara Valley's designated area. Once purchased, users enjoy the freedom to use on any public bus operating within the specified zone without the hassle of buying individual tickets or paying cash for each trip.

A notable advantage of this system is its convenience and flexibility, particularly for frequent travelers like students and employees. By eliminating the need for purchasing tickets for every ride, it streamlines the commuting process and reduces overall transportation costs. Moreover, it ensures smoother operations within the public transportation network, as buses adhere to their designated routes and schedules instead of competing for passengers.

Overall, the introduction of the bus fare package system has significantly improved the accessibility and affordability of public transportation in Pokhara Valley. By providing a convenient and cost-effective solution for daily commuters, this system enhances the overall commuting experience and contributes to the efficiency of the transportation network.

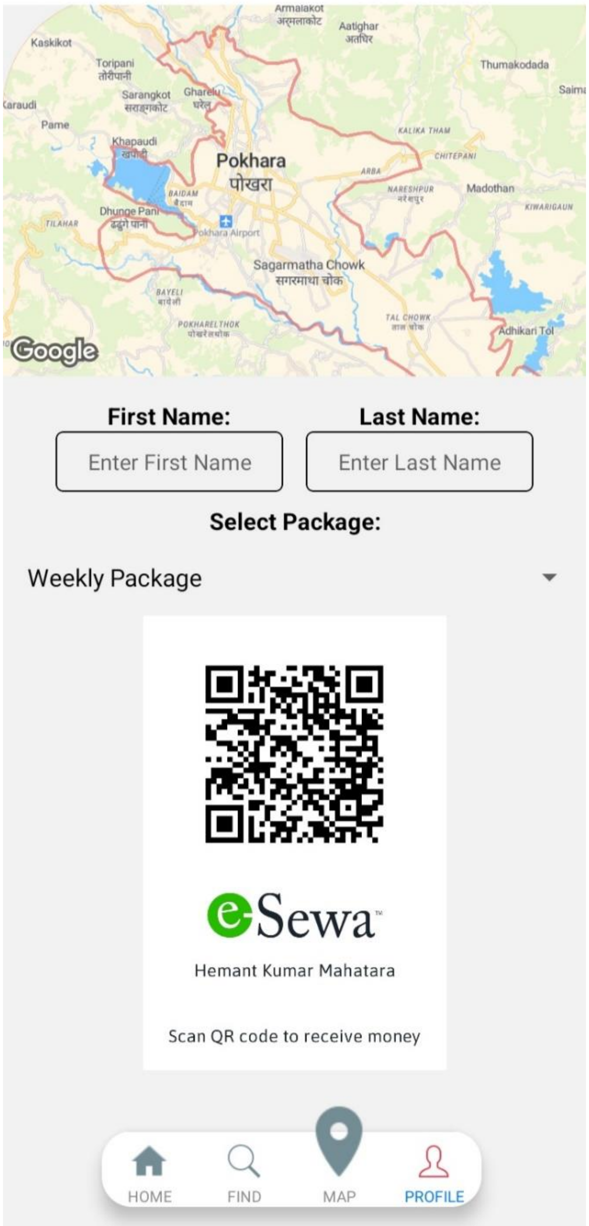


Figure 4-11: Package Purchase Interface in MeroBus App

4.13 Discussion

The implementation of "MeroBus Navigator," a comprehensive mobile app designed for seamless commuting in Pokhara, has resulted in several significant outcomes:

- Improved Commuter Experience: The inclusion of GNSS tracking technology enables commuters to access real-time bus tracking, empowering them to plan their journeys more efficiently and minimize waiting times at bus stops.

- Convenience in Fare Management: Integration of fare information and digital payment options within the app streamlines the ticketing process, offering passengers a convenient way to purchase tickets and passes on the go, enhancing overall convenience for users.

- Enhanced Route Information: "MeroBus Navigator" provides users with comprehensive information about bus routes, schedules, and any updates or changes, ensuring commuters have access to accurate and up-to-date information to facilitate their travel planning.

- Increased Accessibility: The app incorporates accessibility features such as text-to-speech support and high-contrast modes, making it more inclusive and accessible to a wider range of users, including those with disabilities.

- Engagement and Feedback: The inclusion of a feedback mechanism within the app fosters direct communication between users and service providers, facilitating continuous improvements based on user feedback and preferences, ultimately enhancing the overall user experience.

Overall, the implementation of "MeroBus Navigator" has significantly improved the commuting experience for users in Pokhara, offering enhanced convenience, accessibility, and engagement, while also providing valuable tools and features to streamline the process of using public transportation services.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion, the development and deployment of our smart transportation system, as showcased by the "MeroBus Navigator" mobile application, marks a significant stride forward in enhancing the accessibility and efficiency of public transportation in Pokhara. Through features such as real-time bus tracking and predictive arrival times, the application aims to address common commuting challenges and encourage a shift towards using public transportation instead of private vehicles.

Moreover, the potential environmental advantages stemming from reduced private vehicle usage are considerable. Our analysis of pollution emissions from buses compared to motorcycles or bikes underscores the substantial environmental impact of private vehicles. By diminishing the presence of private vehicles on the streets through the implementation of improved public transportation services, we can effectively combat air pollution and foster a cleaner, healthier environment for Pokhara's residents. This underscores the importance of sustainable transportation initiatives in promoting environmental stewardship and enhancing the overall quality of life in urban areas.

5.2 Recommendations

In addition to tracking bus locations, there is a vast potential to expand the capabilities of the Smart Bus Tracking System (SBTS) by integrating particle detection sensors, such as PM 2.5 sensors, into the system. By incorporating these sensors, we can gather air pollution data in real-time at various locations throughout Pokhara Valley. This data collection can be achieved through two methods: static or fixed sensors installed at specific locations or mobile sensors installed on board buses to dynamically measure pollution levels along bus routes.

The inclusion of particle detection sensors opens up avenues for future enhancements to the SBTS. By collecting both location data and pollution levels at each point, we can utilize interpolation techniques to generate heatmaps depicting pollution distribution across the city. These heatmaps can provide valuable insights for policymakers and environmental analysts, aiding in the development of targeted interventions to address pollution hotspots and improve air quality.

Furthermore, integrating real-time pollution data into the "MeroBus Navigator" mobile application can empower users to make informed decisions about their travel routes and take necessary precautions to mitigate exposure to air pollutants. By raising awareness of current pollution conditions, users can actively adjust their travel plans and adopt protective measures, contributing to public health and environmental sustainability efforts.

Furthermore, to enhance the comprehensiveness of our project, it is recommended to conduct Kobo surveys for all bus routes within Pokhara Valley. By expanding the scope of data collection to cover all routes, we can gain a more holistic understanding of commuter preferences, challenges, and satisfaction levels across the entire public transportation network. This extensive data analysis will provide valuable insights for optimizing bus routes, schedules, and services to better meet the needs of commuters.

Additionally, it is recommended to conduct user experience (UI/UX) surveys to gather feedback on the "MeroBus Navigator" mobile application. By asking for input from users regarding the usability, functionality, and design of the application, we can identify areas for improvement and implement enhancements to ensure a seamless and intuitive user experience. Incorporating user feedback into future iterations of the application will contribute to its continuous improvement and increased user satisfaction.

It is recommended to highlight the efficiency of public vehicles by emphasizing their capacity to carry multiple passengers simultaneously. For example, one bus can accommodate up to 40 passengers, which can replace at least 20 motorcycles or scooters. Similarly, one bus can replace 10 cars. By promoting the use of public transportation, the number of private vehicles on the road can be reduced, leading to decreased traffic congestion, fewer accidents, and improved air quality.

Encouraging the use of public vehicles over private vehicles offers significant environmental benefits. Public buses emit fewer pollutants per passenger-kilometre travelled compared to individual motorcycles, scooters, or cars. By opting for public transportation, citizens can contribute to reducing atmospheric pollution and mitigating the adverse effects of vehicular emissions on air quality and public health.

REFERENCES

Thapa, S., Shakya, M., & Gurung, D. B. (2019), "Development and implementation of a real-time bus tracking system using GPS in Kathmandu Valley." *International Conference on Communication and Information Processing* (ICCIP) (pp. 1-5).

Paudel, R., Sharma, B., & Chettri, D. R. (2018), "Feasibility study of real-time bus tracking system for public transportation in Kathmandu valley. "*Fifth International Conference on Social Networks Analysis, Management and Security* (SNAMS) (pp. 197-202).

Shakya, P., & Neupane, P. (2019), "Design and implementation of a real-time bus tracking and passenger information system for Nepal." *International Conference on Computing, Communication and Networking Technologies* (ICCCNT) (pp. 1-5).

Dulal, S., & Khatiwada, S. (2018), "Real-time bus dispatching system for efficient public transportation service in Kathmandu." *Fifth International Conference on Social Networks Analysis, Management and Security* (SNAMS) (pp. 258-263).

Pokhrel, A., Dhungel, M. R., & Rajbhandari, S. (2019), "Evaluating the impact of a real-time bus tracking system in Kathmandu, Nepal." *Case Studies on Transport Policy*, 7(4), 877-885.

Bhattarai, K., Yousef, M., Greife, A., & Lama, S. (2019), "Decision-Aiding Transit-Tracker Methodology for Bus Scheduling Using Real Time Information to Ameliorate Traffic Congestion in the Kathmandu Valley of Nepal." *Journal of Geographic Information System*, (pp. 239-291)

Yu, X., Dong, Y., Yang, F., & Dong, Z. (2009). "Study of Intelligent Public Transport Monitoring System Based on WebGIS." *Second International Conference on Intelligent Networks and Intelligent Systems*.

Kumbhar, M., Survase, M., Mastud, P., & Salunke, A. (2016). "Real-Time Web-Based Bus Tracking System." *International Research Journal of Engineering and Technology* (IRJET), 3(2), ISSN: 2395-0056.

S. Ritier and J. MCCoy, "*Automatic Vehicle Location: An overview. Vehicular Technology*", *IEEE Transactions*, vol. 26, no. 1, pp. 7-11, 1977.

Automatic vehicle location, 2008, [online] Available: http://en.wikipedia.org /wiki/Automatic_vehicle_location.

Vehicle Tracking Systems - Overview, 2008, [online] Available: http://www.roseindia.net/technology/vehicle-tracking/VehicleTrackingSystems.shtml.

Johnson, A., et al. (2020). *Leveraging GNSS Tracking for Public Transport Management: Enhancing Efficiency and Passenger Experience*. Transportation Research, 45(2), 123-136.

Smith, B., & Brown, C. (2019). *Fare Integration and Cashless Transactions in Public Transport: Enhancing Convenience and Efficiency*. Journal of Transportation Systems, 18(3), 201-215.

Yang, X., & Wu, Y. (2021). *User Experience and Adoption Rates of Mobile Applications in Transportation: A Comprehensive Analysis*. Journal of Mobile Technology, 12(4), 301-315.

Lee, S., et al. (2018). *Impact of Real-Time Information on Commuter Behavior: Insights from Mobile Transportation Apps. Transportation Research Part C: Emerging Technologies*, 67, 145-158.

Wang, Q., & Zhang, T. (2020). *Efficiency of Route Planning Algorithms in Mobile Transportation Apps: A Comparative Study. Journal of Transport Engineering*, 25(4), 401-415.

Chen, H., et al. (2019). *Machine Learning for Commuter Analytics in Mobile Apps: Insights and Innovations. Journal of Artificial Intelligence in Transportation Systems*, 15(2), 180-195.

Zhang, Y., & Liu, X. (2020). *Integration of Intelligent Transportation Systems with Mobile Applications for Seamless Commuting. Transportation Research Record*, 2678(1), 25-35.

Park, S., et al. (2019). *Enhancing Commuting Experiences through Multimodal Transportation Integration in Mobile Apps. Journal of Transport Geography*, 77, 102-113.

Kim, J., & Lee, H. (2021). *Gamification Strategies in Mobile Transportation Apps for Enhanced User Engagement. Computers in Human Behaviour*, 125, 106892.

Martinez, A., et al. (2020). *Inclusive Design in Mobile Transportation Apps: Enhancing Accessibility for Users with Disabilities. Journal of Accessibility Studies*, 5(2), 45-58.

Chen, H., et al. (2017). *Dynamic Pricing Strategies in Mobile Apps for Public Transport. Transportation Research Part E: Logistics and Transportation Review*, 105, 102-115.

Li, Y., & Wang, J. (2019). *Crowdsourcing for Real-Time Updates in Mobile Transportation Apps. Journal of Intelligent Transportation Systems*, 24(4), 345-358.

Gupta, R., & Sharma, S. (2021). *Personalized Recommendation Algorithms in Mobile Apps for Public Transport. Computers & Operations Research*, 135, 105150.

Kim, S., et al. (2018). *Safety and Security Features in Mobile Transportation Apps: A User Perspective. Transportation Research Part F: Traffic Psychology and Behaviour*, 58, 386-399.

Singh, P., et al. (2020). *Integration of Mobile Transportation Apps with Smart City Initiatives. Sustainable Cities and Society*, 61, 102349.

APPENDIX A: Mobile Application Pages

Figure A-1: Home Page of MeroBus Application

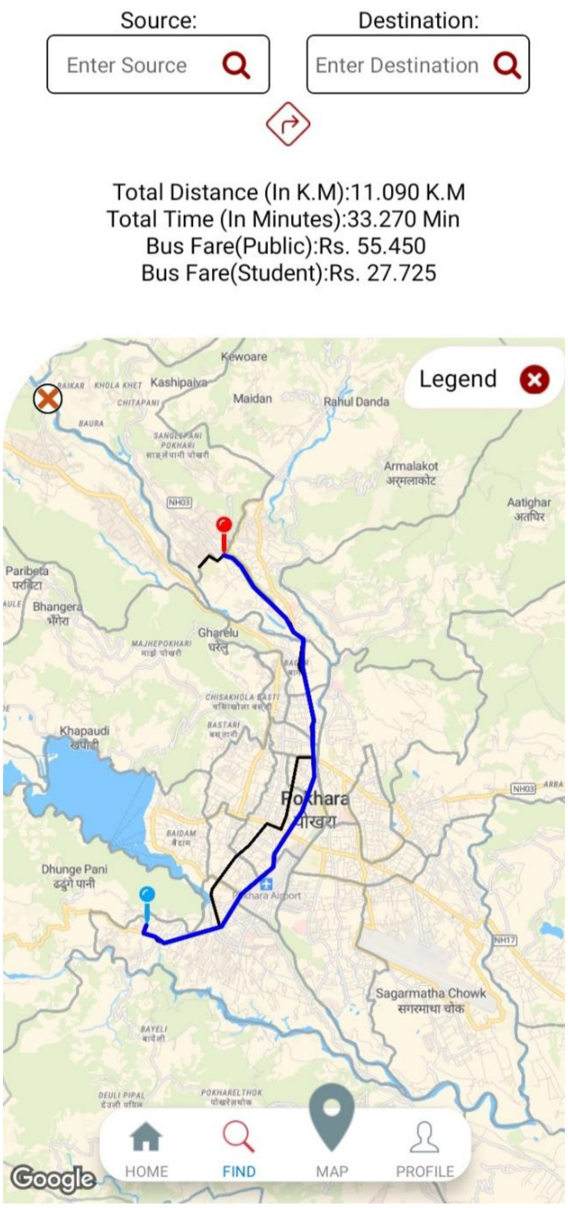


Figure A-2: Routing Page Showing Route Between Source and Destination

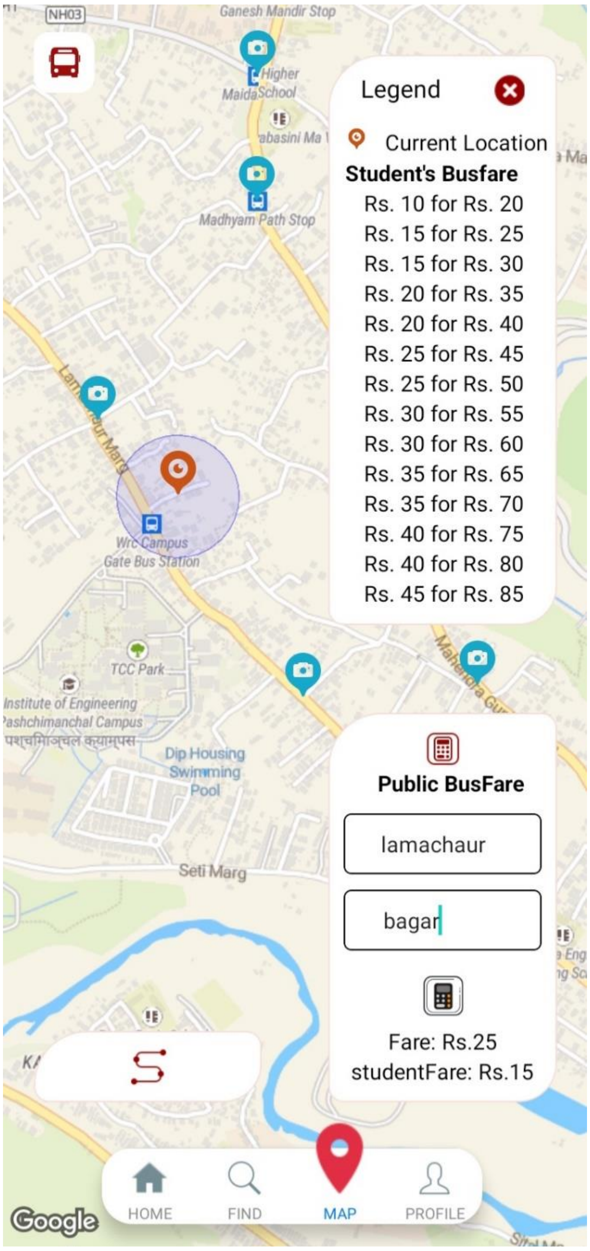


Figure A-3: Bus Fare Calculator Between Source and Destination

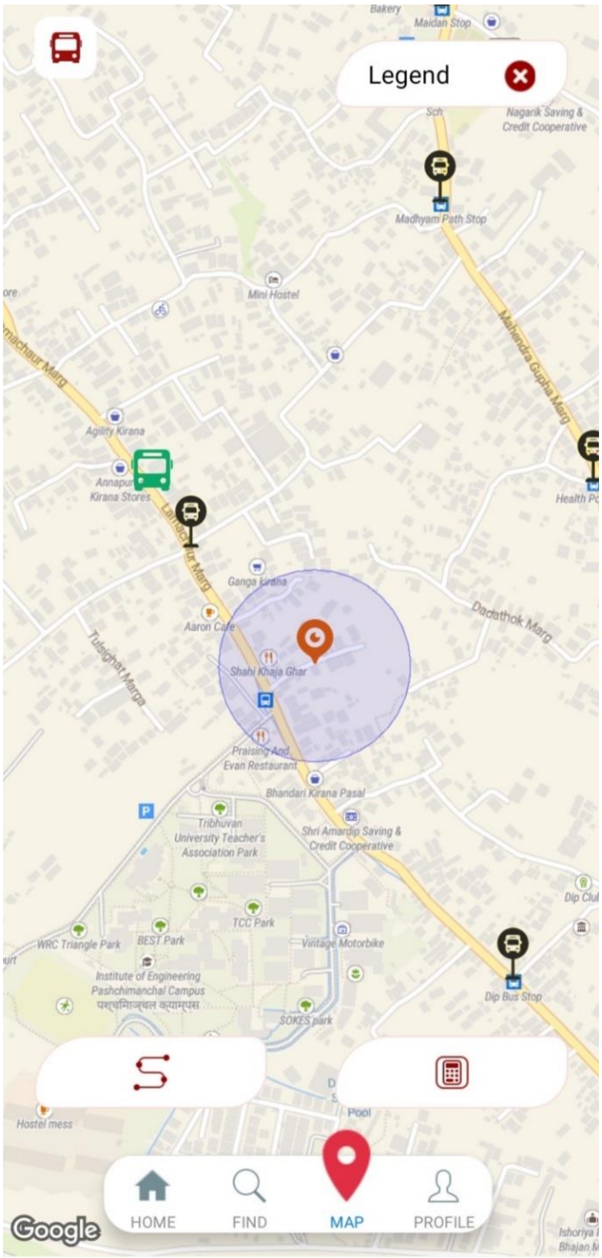


Figure A-4: Map Interface Showing User location and Bus Location(Device Location) in Real Time

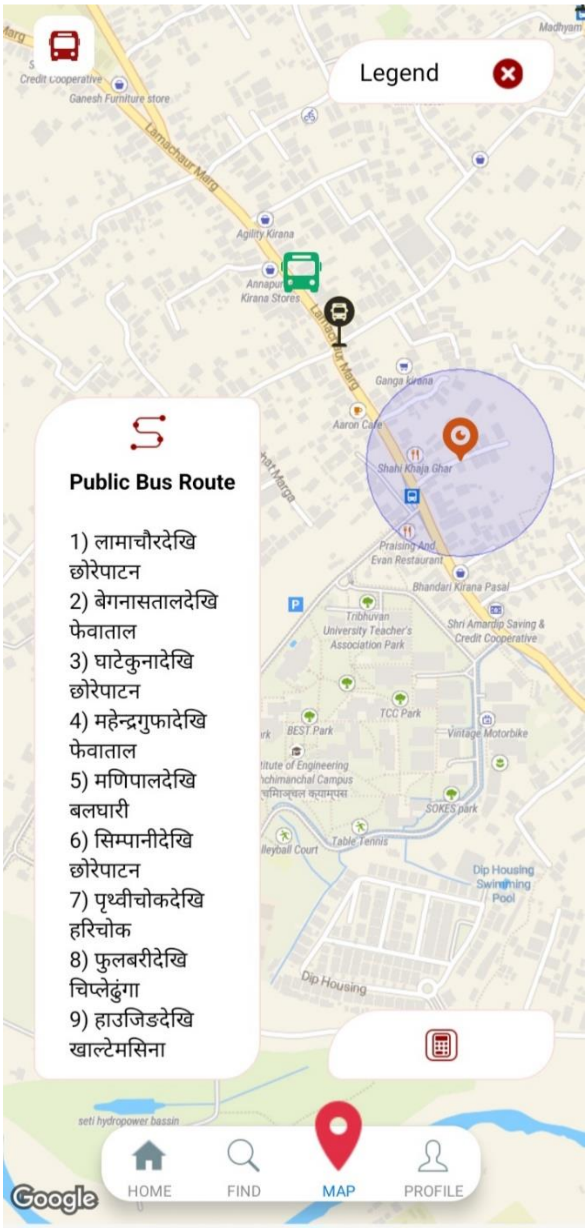


Figure A-5: Map Interface Showing total Route in Pokhara Valley and Nearest Bus Stop within 500m radius from User Current Location

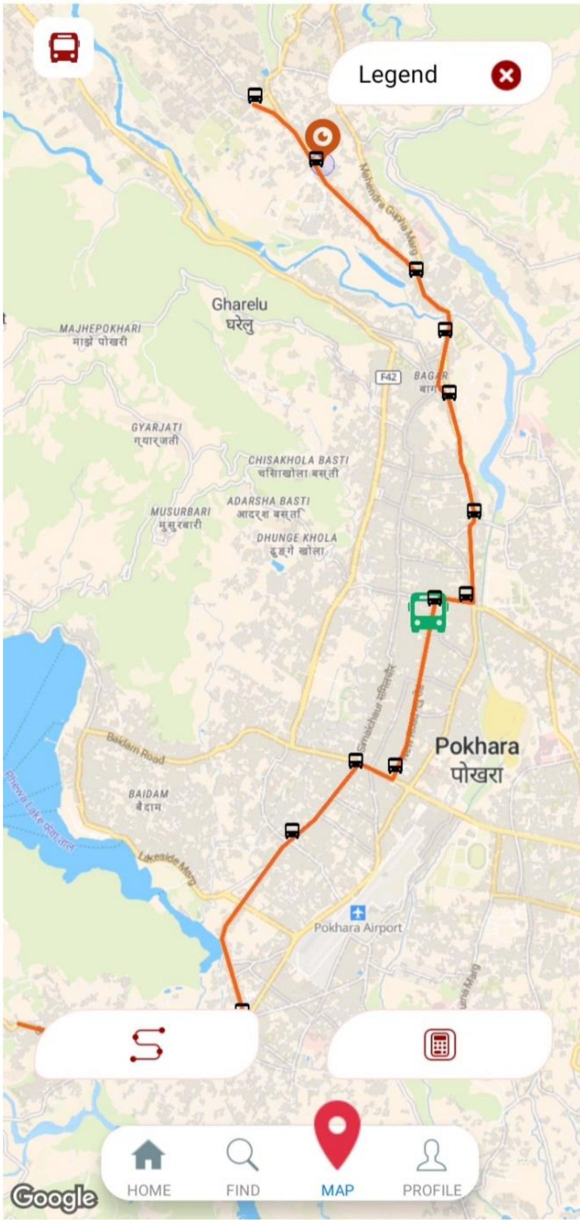


Figure A-6: Route between Lamachaur and Chipledhunga and Bus Stop in this Route

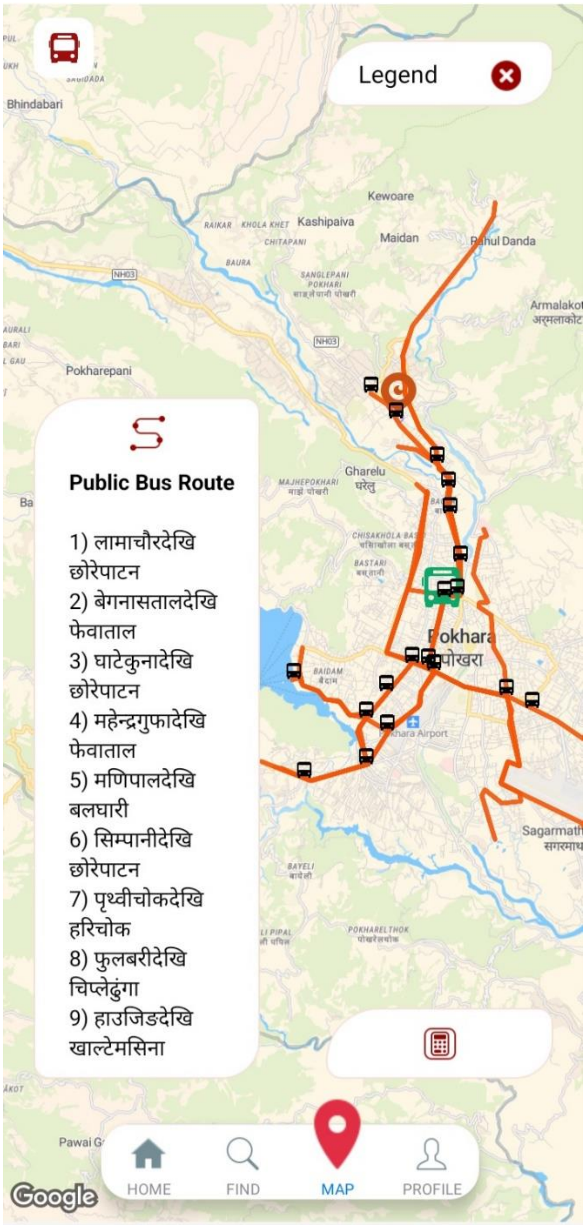


Figure A-7: Total Route Showing in Map Interface

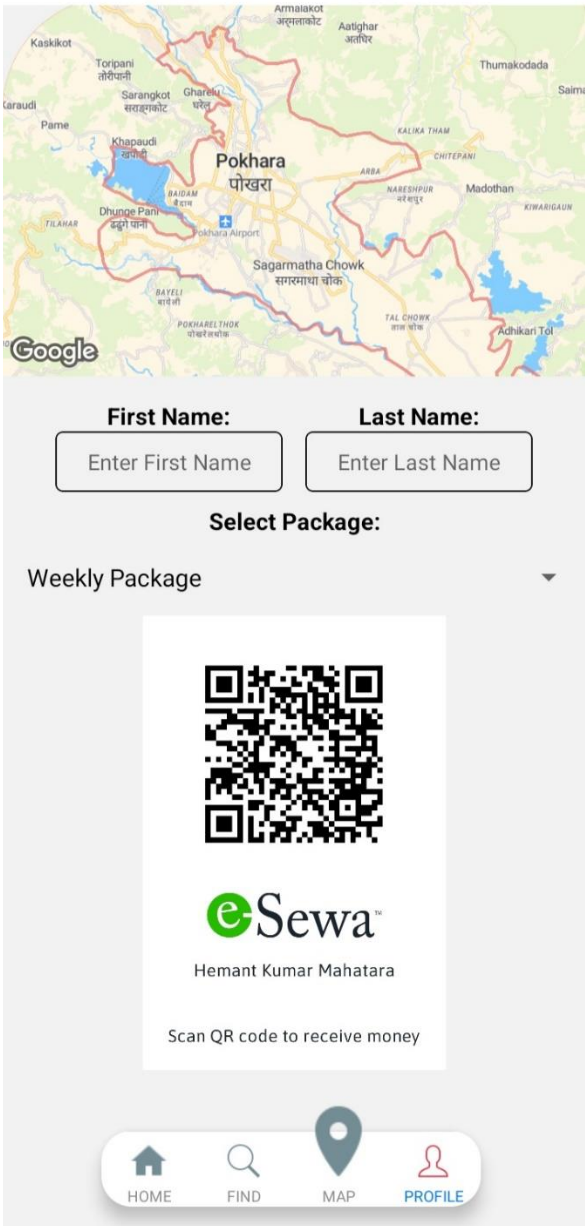
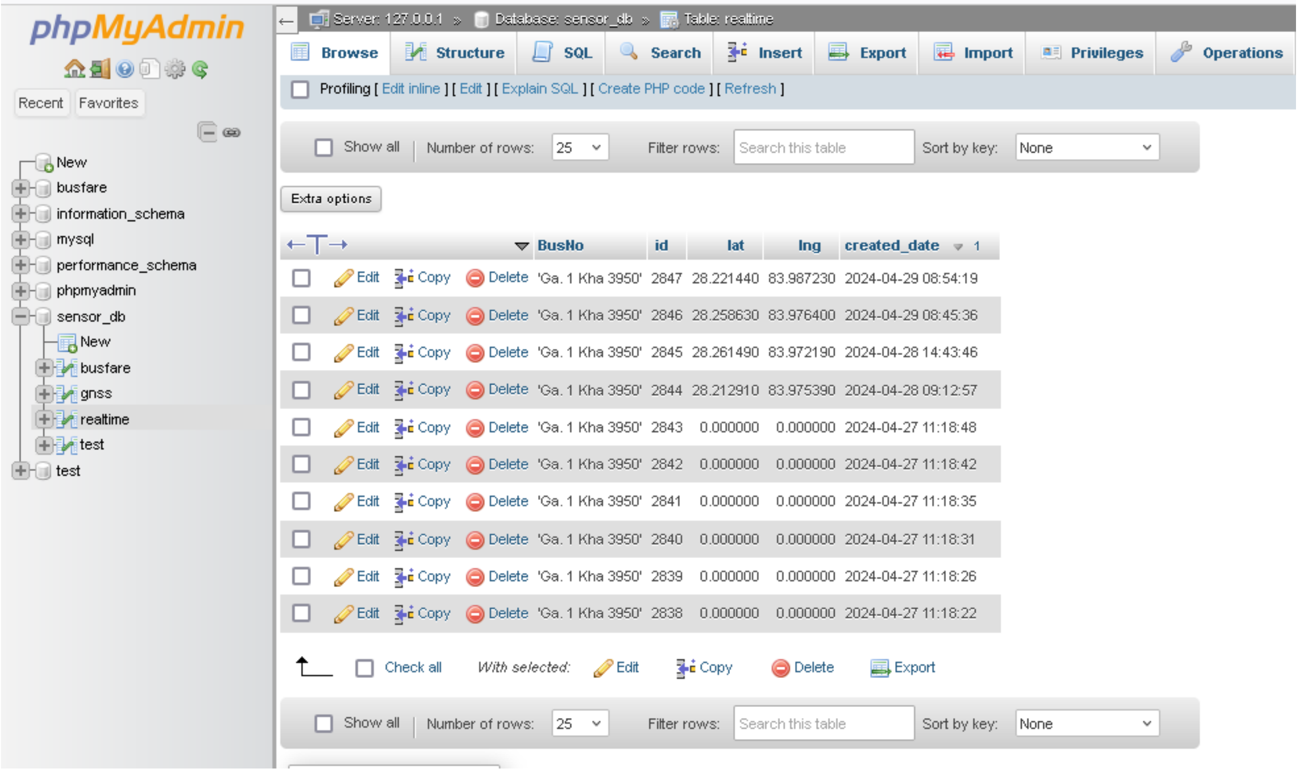


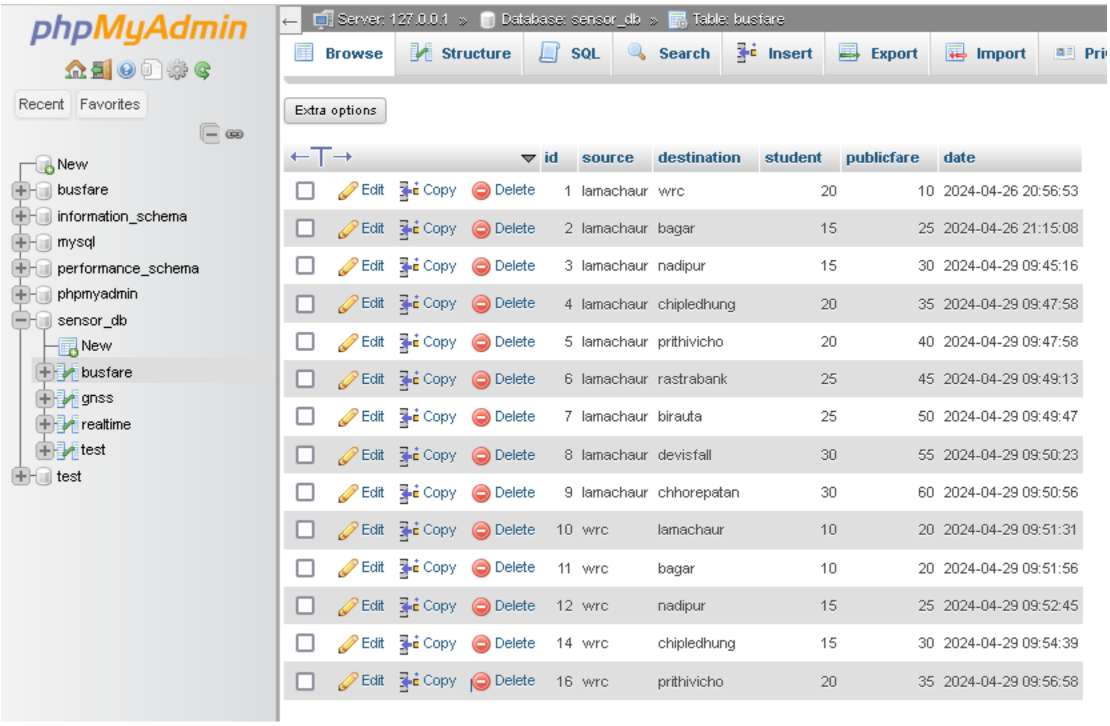
Figure A-8: Payment System

APPENDIX B: Database



BusNo	id	lat	lng	created_date
'Ga. 1 Kha 3950'	2847	28.221440	83.987230	2024-04-29 08:54:19
'Ga. 1 Kha 3950'	2846	28.258630	83.976400	2024-04-29 08:45:36
'Ga. 1 Kha 3950'	2845	28.261490	83.972190	2024-04-28 14:43:46
'Ga. 1 Kha 3950'	2844	28.212910	83.975390	2024-04-28 09:12:57
'Ga. 1 Kha 3950'	2843	0.000000	0.000000	2024-04-27 11:18:48
'Ga. 1 Kha 3950'	2842	0.000000	0.000000	2024-04-27 11:18:42
'Ga. 1 Kha 3950'	2841	0.000000	0.000000	2024-04-27 11:18:35
'Ga. 1 Kha 3950'	2840	0.000000	0.000000	2024-04-27 11:18:31
'Ga. 1 Kha 3950'	2839	0.000000	0.000000	2024-04-27 11:18:26
'Ga. 1 Kha 3950'	2838	0.000000	0.000000	2024-04-27 11:18:22

Figure B-1: Database for Bus Location (Interacting Device and Database at Real Time)



id	source	destination	student	publicfare	date
1	lamachaur	wrc	20	10	2024-04-26 20:56:53
2	lamachaur	bagar	15	25	2024-04-26 21:15:08
3	lamachaur	nadipur	15	30	2024-04-29 09:45:16
4	lamachaur	chipledhung	20	35	2024-04-29 09:47:58
5	lamachaur	prithivicho	20	40	2024-04-29 09:47:58
6	lamachaur	rastrabank	25	45	2024-04-29 09:49:13
7	lamachaur	birauta	25	50	2024-04-29 09:49:47
8	lamachaur	devisfall	30	55	2024-04-29 09:50:23
9	lamachaur	chhorepatan	30	60	2024-04-29 09:50:56
10	wrc	lamachaur	10	20	2024-04-29 09:51:31
11	wrc	bagar	10	20	2024-04-29 09:51:56
12	wrc	nadipur	15	25	2024-04-29 09:52:45
14	wrc	chipledhung	15	30	2024-04-29 09:54:39
16	wrc	prithivicho	20	35	2024-04-29 09:56:58

Figure B-2: Database for Bus Fare

APPENDIX C: Interview Question

A) Personal Information

1) Full Name*

2) Age*

a) 15-20 b)20-25

c) 25-30 d)30 above

3) Gender

a) Male b)Female

4) Occupation*

a)Student b)Teacher

c) Government officer d)Other

5) Did you often use public vehicles in Pokhara?*

a)Yes b)No

a) b)

c) d)

PUBLIC VEHICLES

Section A: Bus System Usage

1) Which routes do you most frequently travel using the bus system?

a) Prithivichowk to harichowk b)Lamachaur to Chorepatan

c) others

2) How do you primarily pay for bus fares in Pokhara

a) Cash b)Smartcard

c)Mobile payment d)other

3) On a scale of 1 to 5, how would you rate the affordability of bus fares in Pokhara? (1 being very expensive, 5 being very affordable)

a) 1 b)2

c)3 d)4

4) On average, how long do you wait for a bus during peak hours?

a) Less than 10 min b)10-20 min

c) 20-30min d)above 30 min

5) How do you primarily learn about bus schedules and routes in Pokhara?

a) Bus station display b)Official websites/map

c) Social medi d)Worth of mouth

6) How often do you encounter issues with the accuracy of posted schedules or route information?

a) Very often b)Often

c) Rarely d)Never

Section B: User Experience and Accessibility

1) Rate the overall convenience of accessing bus stops and the availability of buses?

a) Poor b)Fair

c)Good d)Very good

2) Were the bus schedules clearly displayed and easily accessible at the bus stops?

a) Strongly Disagree b)Disagree

c) Neutral d)Agree

3) Rate the availability of seating on buses during your usual travel times.

a) Often Crowded b)Very Crowded

c) Sometimes Crowded d)Rarely Crowded

4) were the bus announcements (e.g., upcoming stops) audible and helpful during your rides?

a) Strongly Disagree b) Disagree

c) Neutral d) Agree

5) Have you found the bus stations equipped with adequate seating and shelters to protect from weather conditions?

a) Strongly Disagree b) Disagree

c) Neutral d) Agree

Section C: Bus Service Evaluation

1) Rate the cleanliness and maintenance of the buses.

a) Poor b) Fair

c) Good d) Very good

2) How would you rate the punctuality of buses in adhering to the scheduled timings?

a) Very Poor b) Poor

c) Good d) Excellent

3) Have you faced any issues related to overcrowding during your bus travels in Pokhara?

a) Yes b) No

Section D: Suggestions and Improvements

1) Would you prefer the introduction of more environmentally friendly or electric buses in the city's transport system?

a) Yes, I strongly prefer b) Yes, I somewhat prefer it

c) No, I have no preference d) No, I prefer traditional buses

2) What improvements would you suggest to enhance the overall bus system experience in Pokhara?

3) Are there specific routes or timings where you believe the bus service needs improvement? If yes, please provide details.

Section E: Overall Satisfaction

1) How satisfied are you overall with the bus system in Pokhara?

a) Very Dissatisfied b) Dissatisfied

c) Neutral d) Satisfied

2) How likely are you to recommend the bus system in Pokhara to other?

a) Very Unlikely b) Unlikely

c) Neutral d) Likely

2) How likely are you to recommend the bus system in Pokhara to others?

a) Very Unlikely b) Unlikely

c) Neutral d) Likely

3) Do you generally prefer using private or public transportation in Pokhara?

a) Private Transportation (e.g., personal vehicle, taxi, ride-hailing services)
b) Public Transportation (including buses, shared vans/shuttles)

c) Both, depending on circumstances

d) Other (Please specify)

Section F: Future Expectations

1) How important are technological advancements (e.g., real-time tracking, mobile apps for scheduling) in shaping your future transportation preferences in Pokhara?

a) Very Important b) Important

c) Neutral d) Not important

2) Would you be more inclined to use the bus system if there were dedicated times, schedule, lanes and tracking system for buses?

a) Yes, significantly more inclined b) Yes, somewhat more inclined

c) No, it would not impact my decision d) Unsure

3) How important is the integration of Wi-Fi or internet connectivity on buses for your future bus travels?

a) Not Important at All b) Slightly Important

c) Important d) Very Important

4) In what ways do you expect technology to improve your future bus travel experiences in Pokhara? (E.g., better tracking systems, mobile apps, etc.)

PERSONAL VEHICLES

Section A: Personal Vehicles

1) Why do you prefer using a personal vehicle over public transportation?

a) Convenience of having a personal vehicle

b) Lack of reliability in public transport options

c) Specific travel needs that aren't met by public transport

d) Cost-effectiveness of using a personal vehicle

2) Which of the following reasons would encourage you to use public transportation more frequently in the future?

a) Reliable bus service b) Safety at bus stops

c) Bus service close to home d) Access to schedule/route information

4) How many vehicles do you currently own or have access to for transportation purposes?

a) One vehicle b) Two vehicles

c) Three or more vehicle d) other (please specify)

5) What is the primary purpose for which you use your vehicle(s)?

a) Commuting to work or school b) Running errands or daily activities

c) Recreation or leisure d) other (please specify)

Section B: Suggestions and Improvements

1) Would you prefer the introduction of more environmentally friendly or electric buses in the city's transport system?

a) Yes, I strongly prefer it b) Yes, I somewhat prefer it

c) No, I have no preference d) No, I prefer traditional buses

2) What improvements would you suggest to enhance the overall bus system experience in Pokhara?

3) Are there specific routes or timings where you believe the bus service needs improvement? If yes, please provide details.

Section C: Overall Satisfaction

1) How satisfied are you overall with the bus system in Pokhara?

a) Very Dissatisfied b) Dissatisfied

c) Neutral d) Satisfied

2) How likely are you to recommend the bus system in Pokhara to others?

a) Very Unlikely b) Unlikely

c) Neutral d) Likely

3) Do you generally prefer using private or public transportation in Pokhara?

a) Private Transportation (e.g., personal vehicle, taxi, ride-hailing services)
b) Public Transportation (including buses, shared vans/shuttles)

c) Both, depending on circumstances

d) Other (Please specify)

Section D: Future Expectations

1) Would you be more inclined to use the bus system if there were dedicated times, schedule, lanes and tracking system for buses?

a) Yes, significantly more inclined b) Yes, somewhat more inclined

c) No, it would not impact my decision d) Unsure

2) How important are technological advancements (e.g., real-time tracking, mobile apps for scheduling) in shaping your future transportation preferences in Pokhara?

a) Not Important at All b) Slightly Important

c) Important d) Very Important

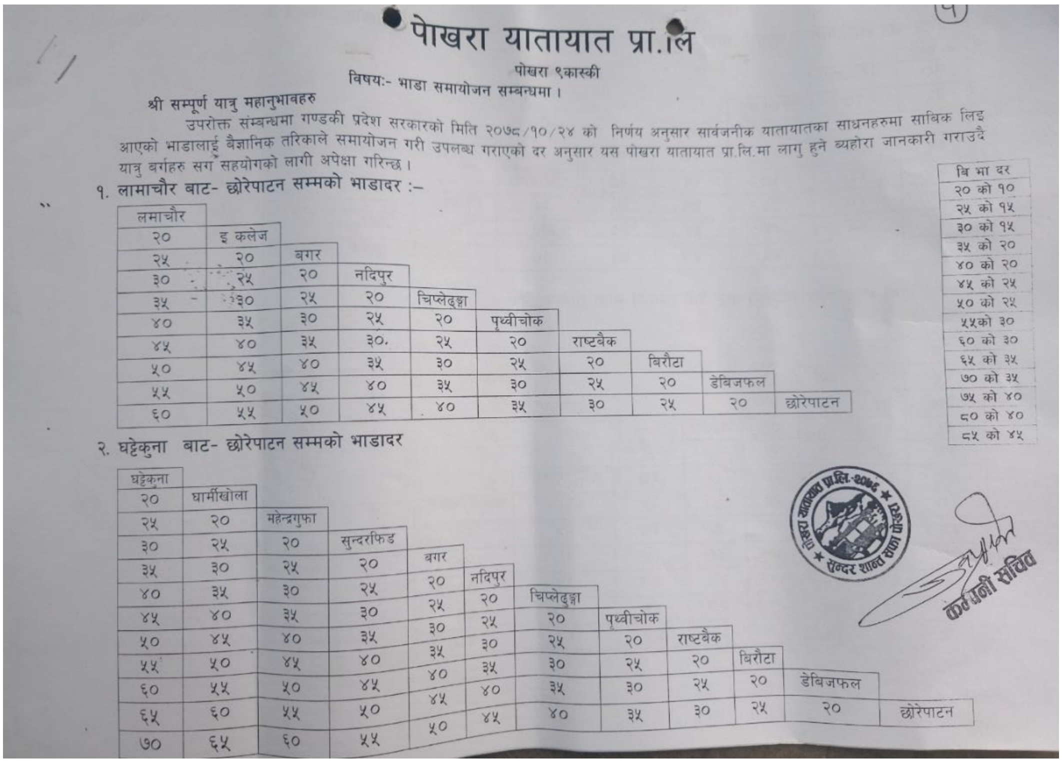
3) How important is the integration of Wi-Fi or internet connectivity on buses for your future bus travels?

a) Not Important at All b) Slightly Important

c) Important d) Very Important

4) In what ways do you expect technology to improve your future bus travel experiences in Pokhara? (E.g., better tracking systems, mobile apps, etc.)

APPENDIX D: Bus fare in Pokhara City



(१)

पोखरा यातायात प्रा.लि

पोखरा ९कास्की

विषय:- भाडा समायोजन सम्बन्धमा ।

श्री सम्पूर्ण यात्रु महानुभावहरु

उपरोक्त संम्वन्धमा गण्डकी प्रदेश सरकारको मिति २०७८/१०/२४ को निर्णय अनुसार सार्वजनीक यातायातका साधनहरुमा साबिक लिइ आएको भाडालाई बैज्ञानिक तरिकाले समायोजन गरी उपलब्ध गराएको दर अनुसार यस पोखरा यातायात प्रा.लि.मा लागु हुने ब्यहोरा जानकारी गराउदै यात्रु बर्गहरु सग सहयोगको लागी अपेक्षा गरिन्छ ।

१. लामाचौर बाट- छोरेपाटन सम्मको भाडादर :-

लमाचौर									
२०	इ कलेज								
२५	२०	बगर							
३०	२५	२०	नदिपुर						
३५	३०	२५	२०	चिप्लेढुङ्गा					
४०	३५	३०	२५	२०	पृथ्वीचोक				
४५	४०	३५	३०.	२५	२०	राष्ट्बैक			
५०	४५	४०	३५	३०	२५	२०	बिरौटा		
५५	५०	४५	४०	३५	३०	२५	२०	डेबिजफल	
६०	५५	५०	४५	४०	३५	३०	२५	२०	छोरेपाटन

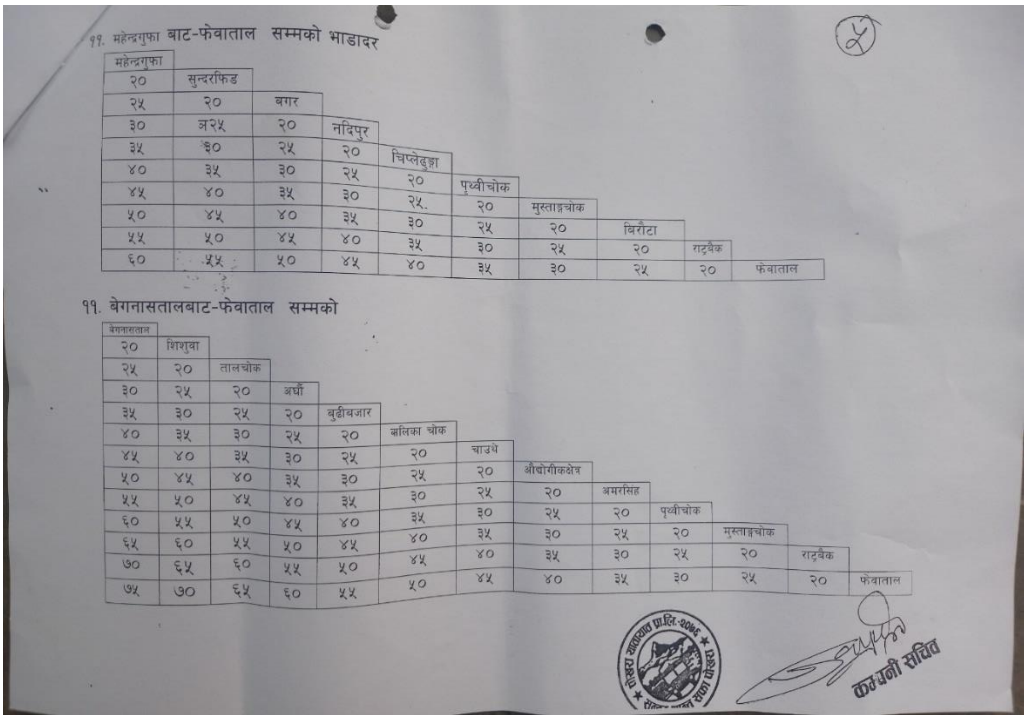
बि भा दर
२० को १०
२५ को १५
३० को १५
३५ को २०
४० को २०
४५ को २५
५० को २५
५५को ३०
६० को ३०
६५ को ३५
७० को ३५
७५ को ४०
८० को ४०
८५ को ४५

२. घट्टेकुना बाट- छोरेपाटन सम्मको भाडादर

घट्टेकुना											
२०	घार्मीखोला										
२५	२०	महेन्द्रगुफा									
३०	२५	२०	सुन्दरफिड								
३५	३०	२५	२०	बगर							
४०	३५	३०	२५	२०	नदिपुर						
४५	४०	३५	३०	२५	२०	चिप्लेढुङ्गा					
५०	४५	४०	३५	३०	२५	२०	पृथ्वीचोक				
५५	५०	४५	४०	३५	३०	२५	२०	राष्ट्बैक			
६०	५५	५०	४५	४०	३५	३०	२५	२०	बिरौटा		
६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	डेबिजफल	
७०	६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	छोरेपाटन

कम्पनी सचिव

Figure D-1: Bus Fare between Lamachaur-Chhorepatan and Ghattekuna-Chhorepatan



(५)

११. महेन्द्रगुफा बाट-फेवाताल सम्मको भाडादर

महेन्द्रगुफा									
२०	सुन्दरफिड								
२५	२०	बगर							
३०	ज२५	२०	नदिपुर						
३५	३०	२५	२०	चिप्लेढुङ्गा					
४०	३५	३०	२५	२०	पृथ्वीचोक				
४५	४०	३५	३०	२५.	२०	मुस्ताङ्गचोक			
५०	४५	४०	३५	३०	२५	२०	बिरौटा		
५५	५०	४५	४०	३५	३०	२५	२०	राट्रबैक	
६०	५५	५०	४५	४०	३५	३०	२५	२०	फेवाताल

११. बेगनासतालबाट-फेवाताल सम्मको

बेगनासताल												
२०	शिशुवा											
२५	२०	तालचोक										
३०	२५	२०	अर्घौं									
३५	३०	२५	२०	बुढीबजार								
४०	३५	३०	२५	२०	बालिका चोक							
४५	४०	३५	३०	२५	२०	चाउथे						
५०	४५	४०	३५	३०	२५	२०	औद्योगीकक्षेत्र					
५५	५०	४५	४०	३५	३०	२५	२०	अमरसिंह				
६०	५५	५०	४५	४०	३५	३०	२५	२०	पृथ्वीचोक			
६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	मुस्ताङ्गचोक		
७०	६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	राट्रबैक	
७५	७०	६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	फेवाताल

कम्पनी सचिव

Figure D-2: Busfare Table from Mahendragufa-Fewalake and Begnaslake-Fewalake

५. मझेरीपाटन वाट सिम्पानी सम्मको भाडा [illegible]लिका

मझेरीपाटन							
२०	बेलचौतारा						
२५	२०	चाउथे					
३०	२५	२०	अमरसिहचोक				
३५	३०	२५	२०	पृथ्वीचोक			
४०	३५	३०	२५	२०	चिप्लेढुङ्गा		
४५	४०	३५	३०	२५	२०	बा.बसपार्क/बगर	
५०	४५	४०	३५	३०	२५	२०	सिम्पानी

६. मणिपाल बाट बेलघारी सम्मको भाडा तालिका :–

मणिपाल									
२०	भास्कर/नारनस्थान								
२५	२०	महेन्द्रपुल/रानिपौवा							
३०	२५	२०	पं.क्षे. स्पताल						
३५	३०	२५	२०	अमरसिहचोक					
४०	३५	३०	२५	२०	पृथ्वीचोक				
४५	४०	३५	३०	२५	२०	राष्टबैंक			
५०	४५	४०	३५	३०	२५	२०	बिरौटा		
५५	५०	४५	४०	३५	३०	२५	२०	डेबिजफल	
६०	५५	५०	४५	४०	३५	३०	२५	२०	बेलघारी

७. फुलबारी बाट चिप्लेढुङ्गा सम्मको भाडा तालिका :–

फुलबारी					
२०	गलेस्वर चोक				
२५	२०	रामबजार			
३०	२५	२०	अमरसिह		
३५	३०	२५	२०	पृथ्वीचोक	
४०	३५	३०	२५	२०	चिप्लेढुङ्गा

कम्पनी सचिव

Figure D-3: Busfare from Majheripatan-Simpani, Manipal-Belghari,Fulbari-Chhipledhunga

८. सिम्पानी बाट- छोरेपाटन सम्मको भाड[illegible] :–

सिम्पानी							
२०	पर्स्याङ्ग						
२५	२०	चिप्लेढुङ्गा					
३०	२५	२०	पृथ्वीचोक				
३५	३०	२५	२०	राष्टबैंक			
४०	३५	३०	२५	२०	बिरौटा		
४५	४०	३५	३०	२५	२०	डेबिजफल	
५०	४५	४०	३५	३०	२५	२०	छोरेपाटन

९. सिम्पानी बाट-महत्तगौडा सम्मको भाडादर :–

सिम्पानी							
२०	ब बसपार्क						
२५	२०	चिप्लेढुङ्गा					
३०	२५	२०	पृथ्वीचोक				
३५	३०	२५	२०	शिवमन्दिर			
४०	३५	३०	२५	२०	आँखा अस्पताल		
४५	४०	३५	३०	२५	२०	रातोपैरा	
५०	४५	४०	३५	३०	२५	२०	महत्तगौडा

१०. सिम्पानी बाट-रातोडाँडाँ सम्मको भाडादर :–

सिम्पानी						
२०	चिप्लेढुङ्गा					
२५	२०	पृथ्वीचोक				
३०	२५	२०	अमरसिह			
३५	३०	२५	२०	मियापाटन		
४०	३५	३०	२५	२०	कदममार्ग	
४५	४०	३५	३०	२५	२०	रातोडाँडाँ

कम्पनी सचिव

Figure D-4: Busfare from Simpani-Chhorepatan, Simpani-Mahatgaida, Simapni-Ratodanda

३. हाउजिङ्ग वाट खाल्टेमसिना सम्मको भाडा तालिका

खाल्टेबाट								
२०	भेडीफारम							
२५	२०	निराजन चोक						
३०	२५	२०	बालिका क्या					
३५	३०	२५	२०	अमरसिह				
४०	३५	३०	२५	२०	पृथ्वीचोक			
४५	४०	३५	३०	२५	२०	चिप्लेढुङ्गा		
५०	४५	४०	३५	३०	२५	२०	बगर	
५५	५०	४५	४०	३५	३०	२५	२०	हाउजिङ्ग

४. नारेस्वर डाँडाँ (अमलचौर)चौतारी वाट सेदी सम्मको भाडा तालिका

नारेस्वर डाँडाँ बयरघारी												
२०	खहरे											
२५	२०	कसेरी										
३०	२५	२०	साझा									
३५	३०	२५	२०	काँउखोल								
४०	३५	३०	२५	२०	गैडाको मुख							
४५	४०	३५	३०	२५	२०	प.क्षे/सितलदेवी						
५०	४५	४०	३५	३०	२५	२०	महेन्द्रपुल चिप्लेढुङ्गा					
५५	५०	४५	४०	३५	३०	२५	२०	नगरपालिका/ट्याक्सीसमिती				
६०	५५	५०	४५	४०	३५	३०	२५	२०	सृजनाचोक			
६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	जरेबर		
७०	६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	हल्लनचोक	
७५	७०	६५	६०	५५	५०	४५	४०	३५	३०	२५	२०	सेदी

कम्पनी सचिव

Figure D-5: Busfare from Housing-Khaltemasina