KNOWLEDGE IN ACTION

School of Transportation Sciences

Master of Transportation Sciences

Master's thesis

Leveraging intelligent mobility solutions in alleviating passenger overcrowding at commuter bus stops in Dar es Salaam - Tanzania

Curthbert Njele

Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences

SUPERVISOR :

Prof. dr. ir. Ansar-Ul-Haque YASAR

CO-SUPERVISOR :

Dr. Emmanuel MCHOME

2024
2025

KNOWLEDGE IN ACTION

www.uhasselt.be
Universiteit Hasselt
Campus Hasselt:
Martelarenlaan 42 | 3500 Hasselt
Campus Diepenbeek:
Agoralaan Gebouw D | 3590 Diepenbeek

School of Transportation Sciences

Master of Transportation Sciences

Master's thesis

Leveraging intelligent mobility solutions in alleviating passenger overcrowding at commuter bus stops in Dar es Salaam - Tanzania

Curthbert Njele

Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences

SUPERVISOR :

Prof. dr. ir. Ansar-Ul-Haque YASAR

CO-SUPERVISOR :

Dr. Emmanuel MCHOME

Preface

This thesis is the culmination of an enriching academic journey in the field of transportation sciences, undertaken through the joint Master of Transportation Sciences program offered by Hasselt University and Ardhi University under VLIR-UOS Institutional University Cooperation. The work presented herein reflects not only my academic growth but also my deep personal and professional interest in improving public transport systems, especially within the context of developing cities like Dar es Salaam.

The inspiration behind this study arose from my daily observations of passenger congestion at commuter bus stops in Dar es Salaam. Experiencing the challenges firsthand as both a commuter and transport enthusiast motivated me to investigate practical, data-driven solutions that can enhance operational efficiency and commuter experience. This study represents my commitment to contributing to sustainable urban mobility through innovative approaches and policy-relevant research.

I am profoundly grateful to my supervisors, Prof. Dr. Ir. Ansar Yasar from Hasselt University and Dr. Emmanuel Mchome from Ardhi University, whose guidance, encouragement, and critical insights have shaped this work. I also extend my appreciation to the sponsor of my scholarship VLIR-UOS Institutional University Cooperation, and agencies that I worked with during the search for and collection of data, namely, Land Transport Regulatory Authority (LATRA), Tanzania National Roads Agency (TANROADS), and all respondents who participated in the research. Lastly, I thank my family and peers for their unwavering support throughout this academic journey.

Summary

Urban mobility remains a critical challenge in many developing cities, particularly in Sub-Saharan Africa, where rapid urbanization and population growth have outpaced investments in public transport systems. Dar es Salaam, Tanzania's largest city, is no exception. This study focuses on understanding and addressing the persistent issue of passenger overcrowding at commuter bus stops in Dar es Salaam by exploring the potential of Intelligent Mobility Solutions (IMS) as a transformative approach to public transport planning and operations.

The research was guided by the overarching objective of evaluating how intelligent mobility can alleviate congestion at transit stops, while also analyzing the behavioral, institutional, and infrastructural factors that contribute to the problem. Specifically, the study aimed to identify the underlying causes of overcrowding, assess the current state and awareness of IMS, examine the adaptability of passengers to technological interventions, and evaluate the effectiveness of selected IMS tools in reducing passenger congestion. To provide a theoretical foundation for this investigation, the study applied concepts from Activity-Based Travel Demand Theory, Systems Theory, and the Technology Acceptance Model (TAM), which collectively framed the complex interactions between traveler behavior, technological adoption, and system performance.

Methodologically, the research adopted a mixed-methods design, combining quantitative and qualitative techniques to ensure a holistic understanding of the problem. Data collection involved structured surveys with passengers, GPS-based monitoring of passenger flow, and field observations at key bus stops. Qualitative insights were gathered through interviews with stakeholders from regulatory authorities such as LATRA and DART, as well as with drivers and transport operators. The study focused on high-demand commuter routes, including both conventional daladala services and the Bus Rapid Transit (BRT) system, to reflect a realistic picture of Dar es Salaam's transit ecosystem.

The findings revealed that passenger congestion is driven by a combination of physical, operational, and behavioral factors. Inadequate bus frequencies, poor queuing discipline, lack of real-time passenger information, and infrastructure constraints were all identified as significant contributors. Many passengers reported long wait times, crowding during peak hours, and safety concerns due to aggressive boarding practices. Drivers highlighted irregular scheduling and the absence of digital coordination tools as persistent operational challenges. Institutional actors acknowledged both a lack of coordination and insufficient digital infrastructure, despite their recognition of the value IMS could offer. While general awareness of IMS was low among passengers and drivers, pilot implementations, particularly

within the DART system, showed promising results. These included smoother boarding, improved queuing, and reduced waiting times.

The study concludes that while physical infrastructure improvements remain important, they are not sufficient in isolation to address the depth of the overcrowding problem. A more integrated and intelligent approach is required, one that combines real-time data, passenger information systems, and adaptive scheduling tools with stronger institutional coordination and commuter engagement. The potential for IMS to transform commuter experiences and system efficiency is clear, but its realization depends on overcoming key barriers: limited funding, inadequate digital literacy, institutional fragmentation, and lack of scalable technology pilots.

To address these challenges, the study recommends scaling up the deployment of RTPI systems across major bus corridors, accompanied by digital signboards and mobile-based alerts. Institutional collaboration between LATRA, DART, and local authorities must be strengthened to ensure policy alignment and sustainable implementation. Capacity-building for both drivers and commuters is essential to support the successful adoption of IMS, as is the promotion of inclusive technologies that serve all demographic groups, particularly women and low-income populations. Furthermore, fostering public-private partnerships (PPPs) can accelerate the development and scaling of intelligent mobility tools, while enhancing innovation and investment in Tanzania's transport sector.

This thesis contributes to the field of transportation sciences by demonstrating how intelligent mobility can be effectively contextualized for use in resource-constrained urban environments. It offers a scalable framework for diagnosing and addressing passenger congestion, rooted in empirical evidence and theoretical grounding. The research not only informs policy and planning in Dar es Salaam but also provides a reference point for other African cities experiencing similar transit challenges. By bridging academic inquiry and practical application, this study positions itself as a catalyst for the broader adoption of smart, inclusive, and sustainable urban transport solutions.

Table of Contents

List of Figures

List of Tables

List of Maps

List of Abbreviations

ADB	African Development Bank
AI	Artificial Intelligence
BRT	Bus Rapid Transit
CBD	Central Business District
DART	Dar es Salaam Rapid Transit
DfT	Department for Transport (UK)
GIS	Geographic Information Systems
GPS	Global Positioning System
ICT	Information and Communication Technology
IoT	Internet of Things
ITS	Intelligent Transport Systems
JICA	Japan International Cooperation Agency
KIIs	Key Informant Interviews
LATRA	Land Transport Regulatory Authority
LTA	Land Transport Authority (Singapore)
MRT	Mass Rapid Transit
ODK	Open Data Kit
PHPDT	Peak Hour Peak Direction Traffic
PT	Public Transport
RTPI	Real-Time Passenger Information
SMU	Smart Mobility Unit
SUMATRA	Surface and Marine Transport Regulatory Authority
TAM	Technology Acceptance Model
TOD	Transit-Oriented Development
TfL	Transport for London
UN-Habitat	United Nations Human Settlements Programme
URT	United Republic of Tanzania

1. INTRODUCTION

1.1 Background

Public transportation systems serve as a backbone for urban mobility, facilitating the movement of millions of people daily. Among the critical elements of these systems, bus stops act as key nodes where efficient passenger management is essential to ensure smooth transit operations. However, many cities face persistent challenges related to overcrowding at bus stops, long waiting times, and inefficiencies in scheduling, particularly during peak hours. In developed countries, these issues have been significantly mitigated by integrating intelligent mobility solutions such as Real-Time Passenger Information (RTPI) systems, predictive scheduling, and innovative ticketing technologies. These innovations have not only enhanced the efficiency of public transportation but also improved passenger experience by reducing uncertainty and optimizing transit operations (Tirachini et al., 2013; Liu & Miller, 2020). Cities like Singapore and London exemplify how data-driven mobility solutions can transform public transit by streamlining operations and improving service reliability (Krishnamurthy et al., 2012; World Bank, 2012).

Conversely, in many developing countries, including sub-Saharan Africa, public transportation systems struggle with severe congestion, inconsistent service intervals, and infrastructure limitations. Informal transport modes, such as minibuses and shared taxis, dominate urban transit networks yet often lack structured scheduling and digital tracking systems. This results in unpredictable arrival times, extended passenger waiting times, and an inefficient commuting experience. Studies in cities like Nairobi, Kenya, and Lagos, Nigeria, revealed that the absence of passenger flow monitoring systems further exacerbates these challenges, making it difficult to manage peak-hour demand effectively (World Bank, 2012; Wireko, 2022). Some efforts have been made to integrate ICT-based solutions, such as SMS notifications and mobile tracking applications. Still, barriers like limited internet access, low smartphone penetration, and insufficient investment in digital infrastructure hinder widespread adoption (Msigwa, 2021). Despite these constraints, research suggests that locally adapted, cost-effective digital solutions can improve transit operations in developing urban environments, offering promising interventions for overcrowding issues (Krishnamurthy et al., 2012).

Existing studies have explored various aspects of urban mobility in sub-Saharan Africa, shedding light on transport inefficiencies, regulatory challenges, and opportunities for improvement. For instance, *S*pringer (2022) broadly analyzes urban expansion, accessibility, and transport equity while discussing the connection between urban structure and mobility. However, it lacks a specific focus on bus stop congestion and does not provide empirical data on the role of intelligent mobility solutions in passenger decongestion. Similarly, the World Bank's Stuck in Traffic: Urban Transport in Africa (2011) highlights public transport authorities' fragmented nature, recommending the expansion of minibuses and motorcycles to counter inadequate formal transit services. While these insights are valuable, the study does not explore targeted interventions for alleviating passenger overcrowding at bus stops or evaluate the potential of innovative mobility technologies in optimizing passenger flow.

Efforts to reform informal transport services have also been studied, particularly in Kigali, Rwanda, where the Mobilise Your City (2019) report examined regulatory frameworks and the role of private sector participation in improving public transport. Although these findings provide valuable perspectives on governance and operational improvements, they fail to address strategies for addressing passenger crowding at bus stops or integrating intelligent mobility solutions. In a more technical approach, a recent study published in *PLOS ONE* (2023) focuses on optimizing bus stop layouts by considering passenger flow demand and travel time. However, its theoretical framework lacks empirical validation in real-world settings, particularly in developing regions where digital infrastructure and smart device access remain limited.

In Tanzania, particularly in Dar es Salaam, public transport largely depends on informal minibusses known as "daladala," which cater to the city's rapidly growing urban population (Chengula et al., 2017). Passenger congestion at bus stops remains a critical issue along high-demand routes, often leading to long queues, overcrowding, and safety hazards for commuters. The absence of RTPI systems and structured scheduling further compounds these challenges, as passengers are uncertain about bus arrivals and availability. Overcrowded bus stops contribute to delays, passenger frustration, and heightened risks of accidents, especially in high-traffic zones (Tirachini et al., 2013). On the other hand, the lack of real-time data collection mechanisms limits the ability of transit operators and authorities to optimize bus schedules, leading to inefficiencies in service delivery (Msigwa, 2021).

To address some of these transit challenges, Dar es Salaam introduced the Bus Rapid Transit (BRT) system, known as the Dar es Salaam Rapid Transit (DART). The system was designed to provide an alternative to the Daladala network by offering scheduled services, dedicated lanes, and higher-capacity buses (World Bank, 2018). While DART has contributed to improving urban mobility, it has not fully alleviated congestion at bus stops, as issues such as overcrowding, inadequate fleet size, and limited network coverage still exist. As a result, many passengers rely on commuter busses (Daladala) system, which remains the dominant public transport mode despite its operational isolation (inefficiencies).

The presence of the DART system highlights the potential benefits of structured transit planning and intelligent mobility solutions in mitigating bus stop congestion. However, these solutions must be tailored to the realities of the Daladala network to ensure inclusivity for all socio-economic groups. By leveraging intelligent mobility solutions such as predictive scheduling, real-time passenger monitoring, and adaptive infrastructure planning urban transit systems in Dar es Salaam can improve passenger flow management and reduce overcrowding at bus stops. Addressing these issues is crucial to enhancing commuter experience, increasing transit efficiency, and fostering sustainable urban mobility.

1.2 Problem Statement

Public transportation systems in many developing countries, including Tanzania, are mostly associated with inefficiencies in passenger management at bus stops. Rapid urbanization and population growth have amplified overcrowding, which then results into long wait times, delays, and unsafe conditions at these critical transit nodes. These challenges disrupt the overall efficiency of transportation networks and negatively impact passenger safety and comfort.

Although intelligent mobility solutions have shown promise in improving public transport globally, their implementation in Sub-Sahara Africa remains limited.

In addition, despite global technological advancements, little attention has been paid to integrating these intelligent solutions into Sub-Sahara's bus stop management systems. This gap in knowledge and application is critical, as the potential of smart mobility to alleviate overcrowding at bus stops and improve operational efficiency remains largely untapped. Therefore, this research aims at addressing this gap by exploring how intelligent mobility solutions, combined with traditional management strategies, can effectively reduce passenger congestion, enhance overall operational efficiency, and improve the passenger experience at bus stops in Sub-Saharan Africa.

1.3 Research Objectives

1.3.1 Main Objective

The primary objective of this research is to explore the potential of intelligent mobility solutions in mitigating passenger overcrowding at commuter bus stops in Sub-Saharan Africa, focusing on enhancing operational efficiency and improving the passenger experience.

1.3.2 Specific Objectives

i. To identify the key factors contributing to overcrowding at bus stops, considering infrastructure, operational, and behavioral aspects.

ii. To assess the role of intelligent mobility solutions and institutional frameworks in addressing passenger congestion.
iii. To explore passenger behavior and adaptability in response to intelligent-based mobility interventions for decongestion.
iv. To assess the effectiveness of various intelligent mobility solutions in reducing overcrowding and improving bus stop operations.

1.4 Research questions

i. What key factors contribute to overcrowding at bus stops, considering infrastructure, operational, and behavioral aspects?
ii. How do intelligent mobility solutions and institutional frameworks influence passenger decongestion at bus stops?
iii. How do passenger behavior and adaptability impact the effectiveness of ICT-based interventions for decongestion?
iv. What innovative mobility solutions can best be adopted to reduce overcrowding at bus stops?
v. How effective are various intelligent mobility solutions in reducing passenger overcrowding and improving operational efficiency at bus stops in Dar es Salaam?

1.5 Significance of the study

This study is significant as it contributes to the growing knowledge of urban mobility by addressing the persistent issue of passenger congestion at bus stops in Sub-Saharan Africa. The research provides valuable insights for policymakers, transport planners, and stakeholders seeking to enhance public transport efficiency by analyzing congestion patterns, identifying key contributing factors, and evaluating the role of intelligent mobility solutions. Furthermore, the study bridges knowledge gaps in the applicability of intelligent mobility solutions within Sub-Saharan Africa, offering context-specific recommendations for improving passenger flow. Ultimately, the findings will inform evidence-based decision-making, support sustainable urban transport planning, and improve the overall commuter experience in Tanzania and similar sub-Saharan African contexts.

2. LITERATURE REVIEW

2.1 Introduction

This Chapter comprehensively examines existing research, policies, and case studies on passenger congestion at bus stops. It explores key terminologies, global agreements, and best practices in managing passenger flow, drawing insights from international and sub-Saharan African contexts. Additionally, the review examines national policies and regulatory frameworks in Tanzania to identify gaps and opportunities for improving bus stop operations. By synthesizing relevant studies, this chapter establishes the foundation for the research, highlighting existing knowledge, best practices, and areas requiring further investigation to inform effective decongestion strategies.

2.1.1 Definition of Key Terminologies

To establish a foundational understanding of this study, it is essential to define key terminologies relevant to passenger decongestion and public transport systems:

Intelligent Mobility:

Intelligent mobility refers to integrating advanced technologies to aid smooth traffic flow. Solutions like real-time passenger information systems, geospatial analytics, and mobile applications enhance transportation systems' efficiency, safety, and sustainability. They can well be exemplified as components of intelligent mobility (Elassy et al., 2024). For instance, Singapore's Land Transport Authority (LTA) uses predictive analytics to adjust bus schedules dynamically during peak hours, ensuring better resource allocation and passenger satisfaction (Krishnamurthy et al., 2012). Intelligent mobility also encompasses Internet Of Things (IoT)-enabled sensors for monitoring passenger flow and AI-based algorithms for traffic management.

Public Transport (PT):

Public transport refers to shared mobility services that facilitate the movement of people within urban and rural areas. PT operates on fixed routes and schedules, making it an essential component of urban mobility and economic development. Public transport systems are critical in reducing congestion, lowering transportation costs, and promoting environmental sustainability. Efficient public transport networks provide access to workplaces, schools, healthcare facilities, and commercial centers, contributing to overall social and economic well-being (JICA, 2018). Public transport exists in various forms, each designed to cater to different mobility needs. The most common forms are;

Mass Rapid Transit:

(MRT) consists of high-capacity rail systems operating on dedicated corridors, carrying a large volume of passengers by rail rapid transit and connecting the peri-urban to the CBD. The capacity of MRT ranges from 20,000 to 60,000 hours of Peak Direction Traffic (PHPDT) in 8-10 coaches at intervals of three minutes. The designed maximum speed is up to 100km/h, while the average range is between 35-45km/h. The length of the trips is medium or long, over 15km, often underground or elevated (JICA, 2018).

Bus Rapid Transit (BRT):

Unlike conventional bus services, BRT operates on dedicated lanes, ensuring minimal interference from other road users. BRT can be incrementally implemented in various environments, from being mixed up with other traffic on streets and highways to totally dedicated rights-of-way. The capacity of BRT ranges from 3,000 to 20,000 PHPDT in 20 seconds of bus travel interval (Mchome, 2021). For instance, Dar es Salaam introduced its BRT system under the Dar es Salaam Rapid Transit (DART) agency, significantly improving urban mobility by providing efficient and affordable transportation to thousands of daily commuters (ADB, 2015). However, further expansion is needed to accommodate the city's growing population and transport demands (Mganda, 2017).

Commuter Rail Transport (CRT);

This is another important public transport mode, particularly in cities with existing railway infrastructure. CRT services in Tanzania are operated by Tanzania Railways Corporation (TRC) and Tanzania-Zambia Railway Authority (TAZARA), providing an alternative mode of transport for passengers commuting between urban and suburban areas (JICA, 2018). Despite its potential, CRT in Tanzania is underutilized due to outdated infrastructure and limited service frequency (Ibrahim et al., 2019).

Commuter Bus Transport (CBT):

CBT is the most widely used form of public transport in Sub-Saharan Africa, accounting for over 90% of public transport trips (LATRA, 2019). It consists of minibusses and mid-sized buses operating within cities and towns, carrying low to medium volumes of passengers by rubber-tired transit along the carriageways that are mixed up with other traffics on streets and highways (Mchome, 2021). In Dar es Salaaam, for instance, the capacity of CBT is 3,000 Peak Hour Peak Direction Traffic (PHPDT) in one minute of the bus travel interval. The designed speed ranges from a maximum speed of 60km/h and an average speed of 5-15km/h depending on the road condition. The trip length is short and it feeds to the BRT, CRT, and MRT (JICA, 2018).

The fact that CBT is the dominant form of public transport in Sub-Saharan Africa, accounting for about 90% of all public transport trips highlights the urgency of special consideration when it comes to the improvement of public transport, which is why this study focuses on improving passenger overcrowding in Commuter bus stops, which are transit nodes within the CBT.

Real-Time Passenger Information (RTPI):

RTPI systems give passengers real-time updates on vehicle locations, arrival times, and service disruptions, enabling informed travel decisions. These systems are commonly displayed on digital screens at bus stops or accessible through mobile apps. For example, Transport for London's (TfL) RTPI system reduces uncertainty for passengers by offering accurate bus arrival times via apps and station displays, leading to improved satisfaction and reduced perceived waiting times (Liu & Miller, 2020).

Passenger Decongestion:

Passenger decongestion alleviates overcrowding at transit nodes, such as bus stops, to improve passenger flow, safety, and operational efficiency. This process involves optimizing bus schedules to minimize waiting times, redesigning infrastructure to accommodate larger passenger volumes, and employing ICT-based solutions such as real-time passenger information systems. For instance, the implementation of queue management systems at London's Victoria Station significantly reduced boarding delays and improved passenger flow (Liu & Miller, 2020).

2.2 Global Perspectives

2.1.1 Global Agreements and Policies

Internationally, passenger decongestion at bus stops aligns with broader sustainable urban transport goals. A review of global frameworks and agreements highlights the importance of addressing passenger overcrowding in transportation nodes.

i. United Nations Sustainable Development Goals (SDGs)

SDG 11 emphasizes the need to make cities inclusive, safe, resilient, and sustainable, focusing on access to safe, affordable, and efficient public transportation systems. This goal directly ties into passenger decongestion at bus stops, as overcrowding often compromises safety and accessibility. For example, cities like Bogotá, Colombia, have adopted policies aligning with SDG 11 by expanding their BRT systems, reducing congestion, and improving service reliability through real-time tracking and priority lanes (UN-Habitat, 2020). The SDGs encourage governments to prioritize investment in public transport infrastructure, which indirectly benefits passenger flow and safety at transit nodes.

ii. New Urban Agenda (Habitat III),2016.

Adopted in 2016, the New Urban Agenda calls for integrated urban planning and transport systems to address challenges such as congestion, safety risks, and inefficiencies in public transport. This agenda underscores the importance of transit-oriented development (TOD), which integrates land use and transport planning to create high-density, mixed-use neighborhoods around transit hubs. An example of TOD in practice is Curitiba, Brazil, where integrating bus stops with commercial and residential developments has improved passenger flow and reduced bottlenecks (UN-Habitat, 2016). The New Urban Agenda's emphasis on pedestrian safety and infrastructure upgrades aligns with efforts to decongest bus stops and enhance overall transit efficiency.

iii. Global Environment Facility (GEF) Sustainable Transport Projects

The GEF supports sustainable urban transport initiatives that reduce emissions and alleviate congestion. These projects often incorporate ICT-based solutions to optimize transit operations and improve passenger experiences. For instance, in Mexico City, the GEF-funded "Metrobus" project introduced a fleet of clean-energy buses and a comprehensive RTPI system to reduce overcrowding at key bus stops. Integrating technology with infrastructure upgrades has been instrumental in significantly reducing waiting times and emissions (GEF, 2019). The GEF's emphasis on innovative, scalable solutions provides valuable insights for developing countries seeking cost-effective methods to address passenger congestion.

iv. International Association of Public Transport (UITP)

UITP serves as a global network for public transport stakeholders, offering guidelines, case studies, and best practices for optimizing bus stops and integrating technology into transit systems. UITP's research highlights the importance of passenger flow monitoring and queue management systems in reducing congestion at transit nodes. For example, the organization's case study on Paris' public transport system demonstrates how data-driven scheduling and innovative ticketing systems have improved efficiency and passenger satisfaction (UITP, 2021). The UITP's advocacy for digital solutions and passenger-centric design is particularly relevant for this study, as it aligns with the goal of leveraging ICT to address congestion at bus stops.

2.1.2 Significance of Global Perspectives to This Study

The global perspectives outlined above provide a comprehensive framework for understanding and addressing passenger decongestion at bus stops in aspects like; Policy Alignment: in that International frameworks like the SDGs and the New Urban Agenda emphasize the importance of safe and efficient public transportation, reinforcing the relevance of this study in achieving broader urban sustainability goals.

Technological Innovation: Examples from GEF-funded projects and UITP case studies highlight the transformative potential of ICT-based solutions, such as RTPI systems and predictive analytics, in reducing congestion and improving passenger experiences.

Finally, Integrated Planning: Lessons from TOD initiatives in cities like Curitiba underscore the importance of integrating land use and transport planning to create more efficient transit systems.

2.2 Experiences from Other Countries Worldwide

2.1.1 Singapore

Singapore's public transport system is widely recognized as a global benchmark for efficiency, reliability, and passenger management. The city-state has consistently invested in innovative technologies and policies to optimize its public transportation network, including addressing congestion at bus stops. Key strategies employed by Singapore include:

Deployment of Real-Time Passenger Information (RTPI) Systems; Singapore has implemented RTPI systems across all major bus stops, providing passengers with real-time updates on bus arrival times, service disruptions, and route changes. These systems are accessible via digital screens at bus stops and mobile applications like the MyTransport.SG app. This technology reduces passenger uncertainty, enabling them to make informed travel decisions and minimizing overcrowding at bus stops during peak hours (Land Transport Authority [LTA], 2021). For example, during the morning rush hour, passengers can stagger their arrival times at bus stops based on real-time bus tracking data, thereby reducing congestion and enhancing flow.

Predictive Analytics for Dynamic Scheduling; Singapore leverages predictive analytics to optimize bus scheduling and ensure adequate capacity during peak hours. Data collected from sensors and travel patterns are analyzed to predict passenger demand, enabling dynamic allocation of buses to high-traffic routes. For instance, additional buses are deployed during major events or school holidays to prevent overcrowding at bus stops (Public Transport Council, 2020). This approach not only improves passenger experiences but also enhances operational efficiency by reducing idle times for buses.

Adoption of Cashless Payment Systems: Singapore has embraced cashless payment systems, such as contactless cards and mobile payment platforms, to expedite boarding processes. The EZ-Link card, a contactless payment card, allows passengers to board buses quickly without fumbling for cash or exact change. This reduces dwell times at bus stops, alleviating congestion during busy periods. Studies show that cashless systems can cut boarding times by up to 30%, significantly improving passenger flow (Tan et al., 2019).

Integration of Land Use and Transport Planning; Singapore's government has integrated land use planning with its transport system to ensure seamless connectivity between residential, commercial, and transport hubs. Transit-Oriented Development (TOD) policies prioritize the development of high-density neighborhoods around bus stops and MRT stations. This integration minimizes the distance passengers need to travel to access public transport, reducing pressure on specific bus stops and enhancing overall system efficiency (Chong & Tan, 2022).

Public Education and Engagement; Singapore's public transport authorities actively engage with citizens to promote responsible commuting behavior. Campaigns such as "Give Way to Alighting Passengers" and "Queue Up, Stay Safe" encourage orderly boarding and alighting at bus stops, further mitigating congestion. These initiatives foster a culture of cooperation among passengers, improving the overall commuting experience (LTA, 2021).

2.1.2 Lessons learnt from Singapore

Singapore's experience provides valuable lessons for addressing passenger congestion at bus stops in other contexts, including Tanzania: such insights include.

Technological Innovation: The deployment of RTPI systems and predictive analytics highlights the transformative potential of ICT-based solutions in managing passenger flow. These tools can be adapted to Tanzania's context to reduce waiting times and improve reliability at bus stops.

Policy Integration: Singapore's land use and transport planning integration demonstrates the importance of a holistic approach to urban development. Similar policies could be adopted in Tanzania to address spatial inefficiencies exacerbating congestion.

Efficiency Gains: Cashless payment systems and dynamic scheduling illustrate how small operational changes can significantly reduce dwell times and overcrowding.

Cultural Factors: Public education campaigns in Singapore emphasize the role of commuter behavior in mitigating congestion. Tanzania could benefit from similar initiatives to promote orderly queuing and boarding practices.

2.1.2 United Kingdom

The United Kingdom, particularly London, offers valuable insights into passenger decongestion strategies at commuter bus stops through the innovative measures implemented by Transport for London (TfL). TfL's approach is grounded in technology integration, data-driven decision-making, and infrastructure design improvements. Key strategies include:

i. Comprehensive Real-Time Passenger Information (RTPI) Systems;

TfL has deployed RTPI systems that provide passengers with real-time updates on bus arrivals, service disruptions, and alternative routes. These systems are accessible through mobile applications, such as the TfL Go app, and display screens installed at bus stops. The availability of real-time information empowers passengers to make informed travel decisions, reducing uncertainty and overcrowding at bus stops (TfL, 2023). For example, during service delays, passengers can adjust their plans by taking alternative routes or waiting for less crowded buses, thus distributing demand more evenly across the network.

ii. Integration of Pedestrian-Friendly Designs

TfL has prioritized the integration of bus stops with pedestrian-friendly designs to enhance accessibility and safety. Features such as wider pavements, tactile paving for visually impaired individuals, and well-lit waiting areas create a safer and more comfortable environment for passengers (DfT, 2021). Additionally, TfL has implemented bus stop bypass lanes for cyclists, reducing conflicts between different modes of transport and improving overall traffic flow. These design enhancements encourage orderly passenger behavior, minimizing bottlenecks at bus stops.

iii. Use of Big Data Analytics

TfL utilizes big data analytics to optimize bus routes and schedules. Data from Oyster cards, contactless payment systems, and GPS-enabled buses are analyzed to understand passenger travel patterns and peak demand periods. This information allows TfL to adjust bus frequencies dynamically, ensuring sufficient capacity during busy times and preventing overcrowding at bus stops (Jones & Smith, 2022). For instance, additional buses are deployed on high-demand routes during the morning rush hour, reducing passenger congestion and wait times.

iv. Smart Queue Management Systems

TfL has piloted intelligent queue management systems at major bus stops, where digital screens display boarding instructions and designated queuing areas. These systems help organize passenger flow, ensuring orderly boarding and reducing dwell times. Such measures are particularly effective at busy interchanges like Victoria Station, where multiple bus routes converge (TfL, 2023).

Significance of the United Kingdom's Experience to This Study**;**

The strategies employed by TfL provide critical lessons for addressing passenger congestion at bus stops in Tanzania:

i. RTPI Systems: The success of RTPI systems in London demonstrates their potential to alleviate uncertainty and overcrowding. Tanzania could adopt similar technologies, leveraging mobile applications and digital screens to provide real-time updates at bus stops.

ii. Infrastructure Improvements: The pedestrian-friendly designs implemented in London highlight the importance of inclusive and accessible infrastructure. Adapting such designs in Tanzania could improve safety and encourage orderly passenger behavior.

iii. Data-Driven Planning: The use of big data analytics by TfL underscores the value of data in optimizing public transport operations. Implementing data collection and analysis tools in Tanzania could enable dynamic scheduling and better resource allocation.

iv. Queue Management: The innovative queue management systems piloted in London offer a scalable solution for reducing boarding times and improving passenger flow at busy bus stops in Tanzania.

Drawing on the United Kingdom's experience, this study can identify actionable strategies to address passenger decongestion at bus stops in sub-Saharan Africa, fostering a more efficient and user-friendly public transport system.

2.3 Experiences from Sub-Saharan Africa

2.3.1 Kigali's Commuter Bus Transport System - Rwanda

Inefficiencies, including overcrowding at bus stops, unpredictable service schedules, and limited infrastructure, have long characterized public transportation in African cities. However, Kigali, Rwanda, has emerged as a model city in Sub-Saharan Africa by implementing structured reforms in its Commuter Bus Transport system. Unlike Bus Rapid Transit (BRT) systems, which require significant infrastructure investments, Kigali has improved commuter bus services by formalizing operations, introducing digital fare collection, optimizing routes, and improving passenger information systems. These interventions provide valuable lessons for addressing bus stop overcrowding and improving urban mobility in sub-Saharan Africa. Key Features of Kigali's Commuter Transport System are;Formalization of Public Transport Services:

Before government intervention, Kigali's public transport was dominated by minibusses, similar to daladala operations in Tanzania. Through the Rwanda Utilities Regulatory Authority (RURA), the Rwandan government has successfully improved the sector by licensing a limited number of bus operators and enforcing service quality standards (RURA, 2021). This structured approach has improved fleet management and reduced congestion at bus stops by ensuring scheduled arrivals and departures.

One of the key reforms was the introduction of three major transport companies Kigali Bus Services (KBS), Royal Express, and Rwanda Federation of Transport Cooperatives (RFTC) to replace fragmented operators (Munshi, 2022). This consolidation has improved reliability and efficiency, reducing the chaotic boarding process that typically contributes to congestion at bus stops.

i. Introduction of Smart Card Payment Systems;

In 2015, Rwanda introduced the Tap&Go system, a cashless fare payment method developed by AC Group (AC Group, 2019). This system has significantly reduced boarding times at bus stops by eliminating the need for cash transactions. Studies show that cash-based fare collection increases dwell time per passenger by up to 15-20 seconds, leading to long queues and overcrowding (Bafana, 2020). The introduction of Tap&Go has streamlined passenger movement, enabling quicker boarding and reducing congestion at bus stops.

Furthermore, the Tap&Go system allows authorities to collect real-time data on passenger flows, facilitating better scheduling and route optimization (Ndoli, 2021). This technology-driven approach aligns with the principles of intelligent mobility solutions, demonstrating the potential impact of digital innovations on bus stop decongestion.

ii. Route Optimization and Licensing Regulations

The Rwandan government implemented route optimization and rationalization strategies to address inefficiencies in commuter transport system. RURA developed a route licensing system, ensuring only authorized buses serve designated routes based on passenger demand (RURA, 2022). This intervention has reduced congestion at significant bus stops by preventing unnecessary duplication of services and ensuring even distribution of vehicles across the city.

Additionally, the licensing of limited operators has facilitated the use of larger-capacity buses, reducing the reliance on smaller minibusses, which often lead to excessive passenger buildup at bus stops. The shift from 15-seater minibusses to 30–70-seater buses has improved passenger flow and reduced waiting times at bus stops (Harrison, 2021).

iii. Passenger Information Systems and Real-Time Tracking

A key innovation in Kigali's public transport system is the integration of real-time passenger information systems. While still in its early phases, efforts have been made to equip major bus stops with electronic display boards showing bus arrival times (Karuhanga, 2022). Additionally, mobile applications integrated with Tap&Go provide passengers with real-time updates on bus locations and estimated arrival times, helping them plan their journeys efficiently.

Studies indicate that real-time passenger information (RTPI) systems can reduce perceived waiting times by up to 30% (Watkins et al., 2011). By ensuring that commuters are well-informed, Kigali has minimized unnecessary crowding at bus stops, as passengers no longer cluster at stations without knowing when their bus will arrive.

iv. Infrastructure Upgrades and Designated Bus Stops

Kigali has invested in improving bus stop infrastructure, ensuring that stations are spacious, well-lit, and equipped with shelter facilities (Kigali City Council, 2021). Unlike many African cities where bus stops are informal and unstructured, Kigali has designated official boarding and alighting points, improving passenger flow efficiency.

Furthermore, the government has reorganized the central bus terminal (Nyabugogo) to facilitate smoother passenger movement and reduce congestion hotspots (Manirakiza, 2022). The presence of well-managed bus terminals has helped in preventing overcrowding at intermediate stops by ensuring passengers board from designated points.

v. Integration with Sustainable Urban Mobility Plans

Kigali's urban mobility strategy aligns with Rwanda's Vision 2050, which emphasizes smart transport solutions and sustainable mobility (Government of Rwanda, 2020). The city has been proactive in adopting policies that encourage public transport over private vehicle use, reducing traffic congestion and indirectly alleviating pressure at bus stops.

Additionally, the introduction of non-motorized transport (NMT) lanes and cycling initiatives has encouraged commuters to use alternative transport modes for short-distance trips (Nsabimana, 2022). This multi-modal integration contributes to better overall mobility management, ensuring that bus stops are not overwhelmed by excessive demand.

Lessons from Kigali's Public Transport System for Sub-Saharan African Countries

Kigali's public transport reforms offer valuable lessons that can be adapted by other Sub-Saharan African countries facing similar challenges in urban mobility. By implementing structured regulations, intelligent mobility solutions, and infrastructure improvements, cities across the region can enhance efficiency, reduce congestion at bus stops, and improve the overall commuter experience.

One of the most significant innovations in Kigali has been the adoption of cashless fare payment through the Tap&Go system. Many Sub-Saharan cities still rely on cash transactions, leading to delays and congestion at bus stops. Implementing a similar digital payment system would streamline fare collection, reduce boarding times, and enhance operational efficiency in public transport networks.

Another key lesson is the importance of regulated route licensing and fleet management. Kigali has successfully restructured its public transport system by limiting the number of service providers and ensuring organized bus routes. Other cities in Sub-Saharan Africa, where informal minibus systems dominate, could benefit from similar regulation to prevent service duplication, improve scheduling, and reduce unnecessary congestion at major transit points.

The expansion of real-time passenger information systems is another crucial intervention. Kigali has started integrating digital information boards and mobile-based tracking applications to provide passengers with accurate bus arrival times. Sub-Saharan cities that struggle with unpredictable transit schedules can adopt similar technology to help commuters plan their journeys better, reducing overcrowding at bus stops and transit hubs.

Infrastructure modernization is also a key takeaway. Kigali's investment in well-designed bus stops, with designated boarding areas, shelters, and clear signage, has significantly improved commuter experience. Many African cities lack adequate bus stop infrastructure, leading to disorderly boarding and unnecessary delays. Upgrading transit facilities in a similar manner would create a more organized and efficient system, minimizing passenger congestion at key transit points.

Rwanda's approach to improving Kigali's commuter bus system demonstrates how non-BRT public transport systems can be optimized to enhance efficiency and reduce congestion at bus stops. By implementing digital payment solutions, real-time passenger tracking, route optimization, and infrastructure upgrades, Kigali has transformed its urban transport landscape. These insights are particularly relevant for Tanzania, where similar interventions could help mitigate passenger overcrowding and enhance urban mobility.

2.3.2 Kenya

In Nairobi, efforts to address passenger congestion and improve public transport efficiency have been initiated under the Nairobi Metropolitan Services Improvement Project (NaMSIP). These initiatives focus on leveraging technology and formalizing the city's predominantly informal public transport sector. Key features include:

i. I.Mobile-Based Applications for Real-Time Tracking

Pilot projects have introduced mobile applications that allow passengers to track public buses, providing real-time updates on bus locations and expected arrival times. This technology addresses long-standing issues of uncertainty and prolonged waiting times at bus stops, particularly during peak hours (Maina & Njagi, 2020). For instance, the "Ma3Route" app has gained popularity among Nairobi commuters, offering live traffic updates and route information, thus empowering passengers to make informed travel decisions.

ii. Digital Scheduling Systems for Matatus

Efforts to formalize the informal matatu (minibus) sector have included introducing digital scheduling systems. These systems aim to regulate departure times, reduce overcrowding at bus stops, and enhance service reliability. By integrating digital tools, the city seeks to streamline matatu operations and mitigate the chaotic conditions often associated with this mode of transport (Kamau et al., 2021).

iii. Public Transport Infrastructure Improvements

Infrastructure upgrades, such as constructing modern bus termini with designated boarding and alighting zones, have been undertaken to improve passenger flow and reduce congestion. These facilities include covered waiting areas, ticketing booths, and clear signage to guide passengers, enhancing comfort and safety.

Significance of Kenya's Experience to This Study

Kenya's efforts to improve public transport in Nairobi offer valuable lessons for addressing passenger congestion in Tanzania. The country has introduced digital innovations and regulatory reforms that have enhanced service reliability and improved commuter experiences. These strategies can be adapted to optimize Tanzania's public transport system and alleviate overcrowding at bus stops.

One of the key takeaways from Nairobi is the implementation of real-time passenger information (RTPI) systems. Mobile-based tracking applications, such as *Ma3Route*, have empowered commuters with accurate bus arrival times, reducing uncertainty and improving travel planning. Adopting similar real-time tracking solutions in Tanzania would help minimize wait times at bus stops and prevent unnecessary crowding.

Another significant lesson is the formalization of informal transport services. In Nairobi, digital scheduling systems and increased regulatory oversight have helped bring structure to the chaotic matatu sector. Applying similar reforms to Tanzania's *daladala* system through digital scheduling and regulatory enforcement could enhance service reliability, reduce congestion at bus stops, and create a more organized public transport network.

Lastly, infrastructure modernization has played a crucial role in improving commuter experiences in Nairobi. Investments in modern bus stops, with designated boarding zones, seating, and clear signage, have enhanced passenger safety and efficiency. Upgrading Tanzania's bus stop infrastructure in a similar manner would promote orderly boarding, reduce overcrowding, and create a more user-friendly transit environment

2.4 Public Transport in Dar es Salaam, Tanzania

Dar es Salaam, Tanzania's largest city and economic hub, has a public transport system heavily reliant on commuter buses known as daladalas. These privately owned minibuses play a crucial role in urban mobility, providing affordable and accessible transport to a majority of the city's population. Despite their significance, the daladala system faces numerous challenges, including congestion, poor vehicle conditions, inadequate regulation, and safety concerns. Additionally, with rapid urbanization and population growth, passenger overcrowding at commuter bus stops has become a pressing issue, leading to increased waiting times, service unreliability, and discomfort for commuters.

The public transport system in Dar es Salaam has evolved significantly over the decades. Initially, public transport was managed by the Dar es Salaam Motor

Transport Company (DMT) in 1949, which was later nationalized into Kampuni ya Mabasi ya Taifa (KAMATA) and Usafiri Dar es Salaam (UDA) in the 1970s (Kanyama et al., 2004). However, due to financial and operational inefficiencies, UDA struggled to meet growing urban transport demand, leading to the emergence of privately operated daladalas in the 1980s. By the early 2000s, daladalas had become the dominant mode of transport, catering to more than 90% of commuter trips within the city (SUMATRA, 2011). Despite the later introduction of the Bus Rapid Transit (BRT) system in 2016, daladalas remain a crucial part of Dar es Salaam's public transport network, serving areas not covered by the BRT.

Passenger Growth and Commuter Bus Fleet Expansion

Dar es Salaam's population has been growing at an estimated annual rate of 5.7%, reaching over 6.4 million residents in recent years. Projections indicate an 85% population increase by 2025 compared to the base year 2015, intensifying the demand for public transportation (LATRA, 2021). The city's daily commuter trips exceed seven million, with more than five million relying on public transport, mainly daladalas (Msigwa, 2013).

Despite the increasing demand, fleet expansion has not kept pace. While introducing the BRT system was intended to alleviate pressure on commuter buses (daladalas), its limited coverage and capacity constraints have led to continued reliance on them. The daladala system, which remains unstructured and semi-regulated, struggles to accommodate growing commuter volumes, resulting in overcrowding at bus stops and terminals (JICA, 2008).

Passenger Overcrowding and Waiting Times

The mismatch between the growing number of commuters and the available transportation options has led to severe overcrowding in Dar es Salaam and other urban centres in Tanzania. Studies have shown that passenger overcrowding, especially during peak hours, is a significant risk factor for non-collision injuries among passengers (BMC Public Health, 2022).

Before the BRT implementation, commuters relied primarily on daladalas, which often operated without fixed schedules, leading to unpredictable and extended waiting times. The introduction of the BRT was expected to reduce waiting times and improve service reliability. However, despite these improvements, commuters continue to experience long waiting times even at the BRT stops, this situation results in passengers getting back to the daladala bus transport, which again is inconsistent with schedules (GSAR, 2021).

Challenges facing public transport in Dar es Salaam include;

Traffic congestion which is a major challenge affecting daladala operations in Dar es Salaam. The high number of these minibuses and inadequate road infrastructure lead to severe congestion, especially during peak hours. This situation increases travel time and contributes to higher fuel consumption and environmental pollution (JICA, 2008).

Safety concerns are another pressing issue. Due to weak regulatory enforcement, many daladala operators fail to adhere to safety protocols. Overloading, reckless driving, and poor vehicle maintenance have resulted in frequent accidents and road fatalities, posing significant risks to commuters (Kanyama et al., 2004).

The condition of daladala vehicles further exacerbates transport challenges. Many of these minibuses are old and poorly maintained, making them prone to frequent mechanical failures. Additionally, their high emissions contribute to air pollution in the city, negatively impacting public health (Carlsson-Kanyama et al., 2005).

Another significant challenge is the lack of formal scheduling. Unlike structured public transit systems, daladalas operate without fixed timetables, leading to unpredictability in travel times. This lack of scheduling results in long waiting times, overcrowding at bus stops, and overall inefficiencies in the transport network (JICA, 2008).

Regulatory deficiencies further weaken the efficiency of daladala operations. The fragmented regulatory framework has led to poor enforcement of transport policies, affecting service quality and sustainability. Weak oversight also contributes to issues such as fare exploitation, traffic rule violations, and inadequate working conditions for bus operators (African Development Bank, 2015).

Daladalas remain a vital component of Dar es Salaam’s public transport network, providing essential mobility services to the city’s residents. However, their efficiency is hampered by congestion, poor maintenance, regulatory gaps, and safety issues. The rapid population growth in Dar es Salaam has outpaced the expansion and efficiency of its public transportation system, leading to persistent overcrowding and extended waiting times at commuter bus stops. Addressing these challenges requires a multi-faceted approach involving policy reforms, infrastructure investment, and improved regulatory enforcement. With proper interventions, daladalas can continue to play a key role in Dar es Salaam’s evolving urban transport landscape while offering safer and more reliable services to commuters.

2.5 Tanzania's Transport-related Policies, Programmes, and Regulations

2.5.1 National Transport Policy (2003)

The National Transport Policy (2003) provides a framework for developing efficient and sustainable transport systems in Tanzania. While the policy does not explicitly address passenger congestion at bus stops, it emphasizes the importance of infrastructure improvements and the adoption of modern technologies to enhance service delivery. For instance, the policy highlights the need for coordinated urban transport planning, prioritizing investments in public transport infrastructure, such as bus stops and terminals, to meet the growing demand in urban areas (United Republic of Tanzania, 2003). The policy also encourages integrating ICT tools to improve operational efficiency and passenger experience, laying a foundational framework for addressing transit challenges like overcrowding.

2.5.2 Dar es Salaam Urban Transport Master Plan,2008

The Dar es Salaam Urban Transport Master Plan is a strategic guide for addressing urban mobility challenges in Tanzania's largest city. A key focus of the plan is expanding the Dar Rapid Transit (DART) system, which aims to provide a high-capacity, efficient, and reliable public transport network. The master plan underscores the role of ICT in managing urban transit demand, including deploying Real-Time Passenger Information (RTPI) systems and electronic ticketing to reduce passenger congestion at bus stops (JICA, 2018). For example, the DART system incorporates features such as dedicated bus lanes and modern bus stations equipped with electronic displays, which enhance passenger flow and minimize delays. However, the plan recognizes the need for further investments to scale these solutions and extend their reach to non-BRT routes, where congestion at bus stops remains a pressing issue.

2.5.3 Regulatory Frameworks;

The Surface and Marine Transport Regulatory Authority (SUMATRA), now replaced by the Land Transport Regulatory Authority (LATRA), oversees public transport operations in Tanzania. LATRA's mandate includes ensuring service quality, safety, and compliance with transport regulations. However, existing regulatory frameworks do not specifically address passenger congestion at bus stops. Instead, the focus has been on broader aspects such as fare regulation, vehicle safety standards, and operator licensing (LATRA, 2020). While these measures contribute to overall service quality, the lack of targeted regulations for bus stop decongestion represents a gap that must be addressed to improve passenger experiences and operational efficiency in urban transit systems.

2.5.4 Local Initiatives

Several local initiatives have been undertaken to pilot innovative solutions to improve public transport efficiency and passenger management. For instance, introducing RTPI systems in select DART stations has provided commuters real-time updates on bus arrivals, reducing uncertainty and wait times. Mobile ticketing solutions have also been tested to streamline fare collection and minimize boarding delays. However, these initiatives have faced challenges such as limited funding, inadequate infrastructure, and low levels of digital literacy among users (Msigwa, 2021). Despite these obstacles, the pilot projects demonstrate the potential of ICT-based solutions to address passenger congestion when scaled and implemented effectively.

Tanzania's policies, programs, and regulatory frameworks provide valuable insights into the challenges and opportunities of managing passenger congestion at bus stops. Key lessons include:

Infrastructure Development: Investments in modern bus stops and terminals, as emphasized in the National Transport Policy and the DART Master Plan, are critical for improving passenger flow and reducing overcrowding. ICT Integration: The pilot projects for RTPI systems and mobile ticketing highlight the transformative potential of digital solutions in enhancing operational efficiency and passenger experiences. Regulatory Gaps: The lack of targeted regulations for bus stop decongestion underscores the need for policy interventions to address this issue. Scalability Challenges: The limited scalability of local initiatives points to the importance of securing adequate funding and addressing infrastructure gaps to achieve sustainable improvements.

3. THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1 Introduction

This chapter establishes the theoretical basis for the study by exploring relevant theories that explain passenger flow, congestion patterns, and the adoption of technology-driven interventions. Integrating these theories gives this research a structured perspective on how intelligent mobility solutions can enhance public transport efficiency and improve passenger experiences.

In this study, the theoretical framework draws on well-established theories such as Activity-Based Travel Demand Theory, which examines travel behavior; Queuing Theory, which explains waiting times and congestion at transit nodes; and Systems Theory, which views public transport as an interconnected system. Additionally, the Technology Acceptance Model (TAM) and Smart Mobility and Sustainable Transport Theories are incorporated in this study to understand the adoption of ICT solutions in public transportation. These theories collectively provide insights into the causes of congestion and the effectiveness of ICT interventions in mitigating passenger crowding at bus stops.

The conceptual framework, on the other hand, builds upon these theories by defining the key variables influencing passenger decongestion, such as real-time passenger information systems, infrastructure design, and scheduling optimization. A conceptual model has been developed to illustrate the relationships between independent, dependent, and moderating variables, providing a structured approach to analyzing passenger congestion and potential interventions.

3.2 Theoretical Framework

3.2.1 Activity-Based Travel Demand Theory;

The Activity-Based Travel Demand Theory shifts the focus from aggregate travel patterns to individual decision-making based on daily activities (Ben-Akiva & Bowman, 1998). Unlike traditional trip-based models, which view travel as isolated movements, this theory, founded by F. Stuart Champin Jr in 1974, recognizes that passenger mobility is driven by the need to participate in various activities such as work, education, and leisure (Bhat & Koppelman, 2002).

This theory is crucial in understanding peak-hour congestion at bus stops, as travel demand is not random but follows structured patterns linked to human activity schedules (Axhausen & Gärling, 1992). In Dar es Salaam, for example, the highest congestion levels at bus stops occur during morning and evening peak periods when commuters travel to and from work. By analyzing travel diaries and GPS mobility data, transport planners can identify peak congestion zones and implement targeted decongestion strategies, such as dynamic scheduling and express bus services (Zhao et al., 2019).

A notable application of this theory is seen in London's Transport for London (TfL) system. Big data analytics assess daily passenger flows and optimize transit operations accordingly (Goulet-Langlois et al., 2017). Applying similar approaches in Tanzania could help forecast demand variations and enhance the efficiency of bus stop operations.

3.2.2. Systems Theory;

Systems Theory provides a holistic approach to understanding public transport by viewing it as an interconnected system, where changes in one component impact the entire network (Bertalanffy, 1968). Initially developed in the fields of biology and engineering, this theory has been widely applied in transportation studies to examine how different elements of vehicles, passengers, infrastructure, policies, and technology interact within a transport system (Checkland, 1999).

In the context of passenger congestion at bus stops, Systems Theory suggests that improving one aspect of transit, such as bus frequency or station design, affects other aspects like passenger waiting times, operational efficiency, and service reliability (Forrester, 1971). For instance, if real-time passenger information (RTPI) systems are introduced, they can lead to better passenger distribution across stops, reduced crowding, and improved scheduling (Banister, 2008). Similarly, the introduction of dedicated bus lanes to enhance efficiency might also require adjustments in road network management, traffic signals, and pedestrian access (Hensher & Mulley, 2015).

A real-world example of Systems Theory in action is London's Transport for London (TfL), which integrates big data analytics, RTPI, and contactless payments into a unified system. These changes have collectively improved passenger experience, reduced bus dwell times, and enhanced overall service reliability (Gkiotsalitis & Cats, 2021). Applying similar principles in Tanzania could mean adopting integrated ICT solutions, such as automated fare collection, predictive scheduling, and passenger flow monitoring, to address congestion issues at bus stops.

3.2.3. Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis (1989), explains how and why users adopt new technologies by evaluating two primary factors:

i. Perceived Usefulness (PU) – The extent to which a person believes that technology will improve efficiency.

ii. Perceived Ease of Use (PEOU) – The degree to which a person finds a technology user-friendly and effortless to adopt.

In public transport, TAM helps understand how passengers and operators respond to ICT-based solutions like RTPI, mobile ticketing, and intelligent mobility systems (Venkatesh & Davis, 2000). A key application of this model is in predicting the success of smart mobility initiatives if passengers perceive real-time bus tracking apps as useful and easy to use, they are more likely to adopt them (Kim et al., 2017).

For instance, Singapore's public transport system successfully implemented RTPI and cashless payments because commuters found them reliable and convenient (Chong et al., 2019). In contrast, efforts to introduce similar systems in Nairobi's matatu sector faced resistance due to lack of awareness, perceived complexity, and distrust in digital fare systems (Watkins et al., 2011).

In Tanzania, applying TAM could help assess public attitudes toward mobile-based ticketing and RTPI services, ensuring that solutions are designed to be user-friendly and effectively communicated to passengers. This would facilitate higher adoption rates, reduced boarding delays, and improved passenger distribution at bus stops (Shaaban & Maher, 2020).

3.2.4 Smart Mobility and Sustainable Transport Theory;

The Smart Mobility and Sustainable Transport Theory emphasizes the role of Information and Communication Technology (ICT) in enhancing the efficiency, accessibility, and sustainability of transport systems (Banister, 2018). It integrates digital innovation, intelligent transport systems (ITS), and data-driven solutions to optimize public transportation while minimizing environmental and social costs (Geels, 2012). This theory is grounded in the principles of sustainable urban mobility, which advocate for transport systems that are economically viable, socially inclusive, and environmentally friendly (Docherty et al., 2018).

3.2.5 ICT and Smart Mobility in Public Transport

The adoption of ICT in public transportation has led to the emergence of smart mobility solutions such as real-time passenger information (RTPI), automated fare collection (AFC), intelligent traffic management, and predictive analytics for route optimization (Shaheen & Cohen, 2020). These technologies help to reduce congestion, improve service reliability, and enhance passenger experience. For instance, the deployment of big data analytics in London's bus network has enabled Transport for London (TfL) to optimize bus schedules based on passenger demand, reducing wait times and overcrowding at bus stops (Marsden et al., 2020).

Similarly, Singapore's Smart Mobility 2030 strategy integrates mobile applications, electronic road pricing, and automated transport management to create a seamless and efficient urban transit network (Tan et al., 2019). These innovations demonstrate how intelligent mobility solutions can significantly improve public transport efficiency while reducing congestion.

The Smart Mobility and Sustainable Transport Theory is particularly relevant to addressing passenger congestion at bus stops. Traditional public transport systems often suffer from inefficient scheduling, lack of real-time information, and inadequate infrastructure, leading to overcrowding at transit nodes (Gössling, 2020). By incorporating smart mobility solutions, transport planners can enhance real-time information dissemination, allowing passengers to make informed travel decisions and avoid unnecessary crowding, and Optimize bus schedules and frequencies using predictive analytics, reducing wait times at bus stops (Hickman et al., 2019).

3.3 Conceptual Framework

The conceptual framework serves as the structural blueprint of this study, outlining the key variables and their interrelationships in understanding passenger decongestion at bus stops. It provides a logical explanation of how factors such as passenger demand fluctuations, inadequate real-time information, poor infrastructure, and inefficient scheduling contribute to congestion at bus stops (Creswell & Creswell, 2018). By mapping these variables, the framework helps to identify potential interventions, particularly through the integration of intelligent mobility solutions (Litman, 2021).

3.3.1 Description of Key Variables and their Interactions

The conceptual framework of this study is built around three key categories of variables:

I. Independent Variables (Factors Influencing overcrowding).

Passenger overcrowding at bus stops is driven by several interrelated factors that disrupt transit efficiency and passenger experience resulting to overcrowding at bus stops. From a review of various literature, the common factors influencing overcrowding at bus stops are;

a) Passenger demand fluctuations occur due to ridership variations during peak and off-peak hours, often overwhelming transit systems with surges in demand that create bottlenecks at bus stops and increase passenger wait times (Hickman et al., 2020).
b) The lack of real-time information (RTPI) systems exacerbates this issue by leaving commuters uncertain about bus arrivals and departures, leading to unnecessary

clustering as passengers wait for the next available vehicle without clear information on expected service times (Gkiotsalitis & Cats, 2021).

c) Inadequate bus stop infrastructure, such as insufficient waiting space, poorly designed boarding zones, and limited accessibility features, contributes to congestion by restricting passenger movement and forcing large crowds into small areas, thereby slowing down boarding and alighting processes (Guo & Wilson, 2019).
d) Inefficient scheduling, where uncoordinated arrival and departure times result in bus bunching and irregular service frequencies, leading to overcrowding as multiple buses arrive simultaneously or long gaps between services leave passengers stranded for extended periods (Fielbaum et al., 2020).

These factors collectively strain the transit network, highlighting the need for improved planning, technological integration, and infrastructure development to enhance passenger flow and minimize passenger congestion.

II. Dependent Variable (Passenger Decongestion at Bus Stops)

The dependent variable in this study is the level of congestion at bus stops, which is influenced by the independent variables. Passenger decongestion refers to the extent to which crowding is reduced through better scheduling, improved infrastructure, and the adoption of ICT solutions (Dell'Olio et al., 2018).

III. Moderating variables (Passenger decongesting techniques)

These variables influence the effectiveness of strategies to reduce passenger congestion at bus stops. Such variables include the following sub-variables.

a) Intelligent mobility solutions; These play a crucial role by integrating technologies such as real-time passenger information (RTPI), mobile ticketing, and predictive analytics to streamline transit operations. These solutions enhance efficiency by reducing wait times, improving passenger distribution, and optimizing bus stop usage through better-informed decision-making (Hensher et al., 2020).
b) Policy and regulatory frameworks; which significantly impact congestion management, as government interventions including urban transport policies, regulatory reforms, and infrastructure investments can either facilitate or hinder the success of decongestion strategies. Effective governance ensures that technological advancements and infrastructural improvements align with broader urban mobility goals (Vuchic, 2017).
c) Passenger behavior and adaptation, as the willingness of commuters to embrace digital solutions, modify travel patterns, or opt for alternative transport modes determines the overall effectiveness of implemented measures. Public awareness, user experience, and incentives for behavioral change are essential in ensuring

widespread adoption of decongestion strategies (Zhao et al., 2019). These moderating variables collectively shape the success of congestion mitigation efforts, emphasizing the need for a holistic approach that integrates technology, policy, and commuter adaptability.

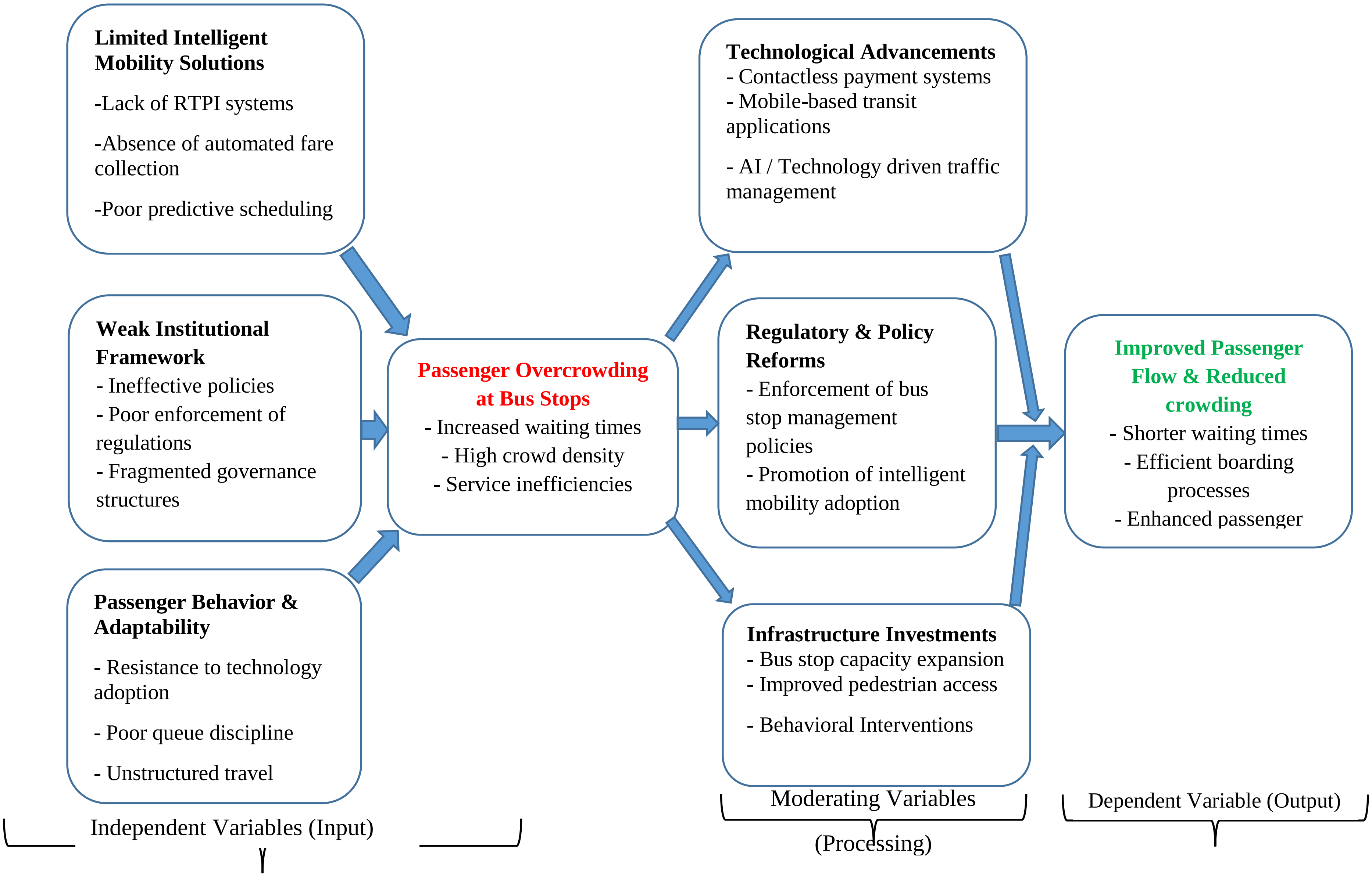


FIGURE 1 Visual Presentation of Conceptual Framework

4. RESEARCH METHODOLOGY

4.1 Introduction

This chapter outlines the research strategy, design, and procedures employed to investigate how intelligent mobility solutions can alleviate passenger overcrowding at bus stops in Tanzania. This chapter provides a systematic framework for conducting the study, ensuring the reliability and validity of findings. The study adopted a mixed-methods research approach, integrating quantitative and qualitative techniques to comprehensively analyze passenger congestion patterns and evaluate the impact of intelligent mobility solutions.

4.2 Research Strategy

This study employed study area selection (case study), and as Kothari (2008) explains that case study research involves a selection of and an intensive investigation of a unit to be studied.this research embodies a mixed-methods research strategy, integrating quantitative and qualitative approaches to develop a comprehensive understanding of passenger decongestion at bus stops. The rationale for adopting this strategy is to leverage the strengths of both research paradigms: the quantitative component provided measurable, statistical insights into overcrowding patterns, while the qualitative component captured stakeholders' perceptions, experiences, and behavioral aspects.

The mixed-methods approach facilitates triangulation, ensuring that findings from different sources are cross-verified for increased accuracy and reliability. Additionally, this strategy enables the study to not only identify overcrowding patterns but also assess the effectiveness of intelligent mobility interventions in real-world settings.

The study is structured to address key research questions through A) Quantitative Analysis; which will be statistical assessment of passenger flow data, GIS-based spatial mapping of congestion, and survey-based analysis. B) Qualitative Analysis that will cover Stakeholder interviews and observational studies to understand behavioral and operational dynamics.

By employing this multi-faceted research strategy, the study ensured a well-rounded examination of passenger congestion issues and potential solutions.

4.3 Research Design & Process

The research design followed a systematic process that integrates multiple components, ensuring a comprehensive and structured investigation into the problem of passenger overcrowding at bus stops. The research process is visually represented in Figure 2, illustrating how various stages are interconnected to achieve the study's objectives.

The study began with experiences, observations, and evidence informing the research issue of passenger overcrowding at urban bus stops. This led to the formulation of research objectives and questions, guiding the selection of appropriate research methods. Afterward, the study followed a series of steps, namely;

Step 1: Literature Review and Conceptual Framework; A thorough literature review was conducted throughout the study to understand existing research on intelligent mobility solutions and passenger congestion. Simultaneously, a conceptual framework was developed, providing a theoretical foundation for analyzing the research problem.

Step 2: Research Strategy and Design. Based on insights from the literature review, a mixed-methods approach was adopted to integrate both qualitative and quantitative perspectives. The exploratory phase helped identify key congestion factors (Research questions 1 & 3), while the explanatory phase examined the relationships between congestion patterns and intelligent mobility interventions (Research question 2&4).

Step 3: Data Collection; The study employed multiple data collection methods, including passenger physical observations (flow monitoring), surveys, structured interviews, and GIS-based spatial analysis and mapping. These methods were designed to capture both numerical data on congestion patterns and qualitative insights from stakeholders.

Step 4: Data Analysis; Collected data underwent systematic analysis where by quantitative data was analyzed using statistical tools such as MS Excel to identify congestion trends and assess the effectiveness of interventions. Qualitative data was be thematically analyzed to understand stakeholder perspectives and operational challenges. Then Geospatial analysis was then applied to visualize congestion hotspots and evaluate spatial distribution patterns.

Step 5: Synthesis and Interpretation: Findings from different data sources were synthesized to ensure a holistic understanding of the problem. This phase also allowed for cross-validation (Triangulation) between quantitative and qualitative insights, ensuring the reliability of conclusions.

Step 6: Conclusion, Recommendations, and Areas for Further Study. The study was concluded by summarizing key findings and providing actionable recommendations for policymakers, transport operators, and urban planners. Additionally, areas for further research were also identified, ensuring that future studies can build upon the findings of this research.

Finally, across every step, the Literature review was conducted to ensure a deeper understanding of the subject matter.

The structured research design ensured that all components of the study are logically connected, leading to a well-founded analysis of intelligent mobility solutions in alleviating passenger overcrowding at commuter bus stops in Tanzania.

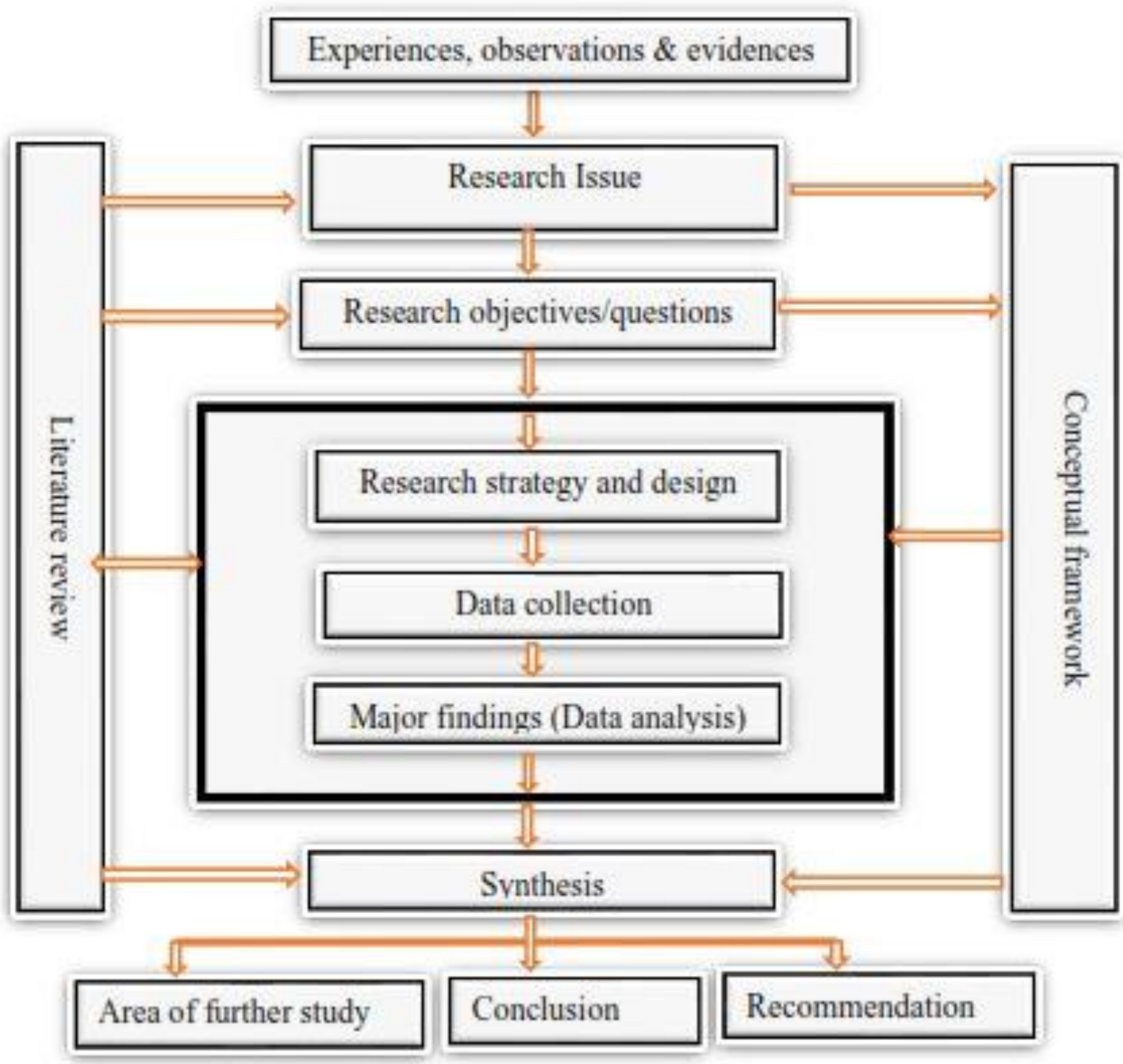


FIGURE 2 Research Process

Source: Author, 2025

4.4 Study area selection

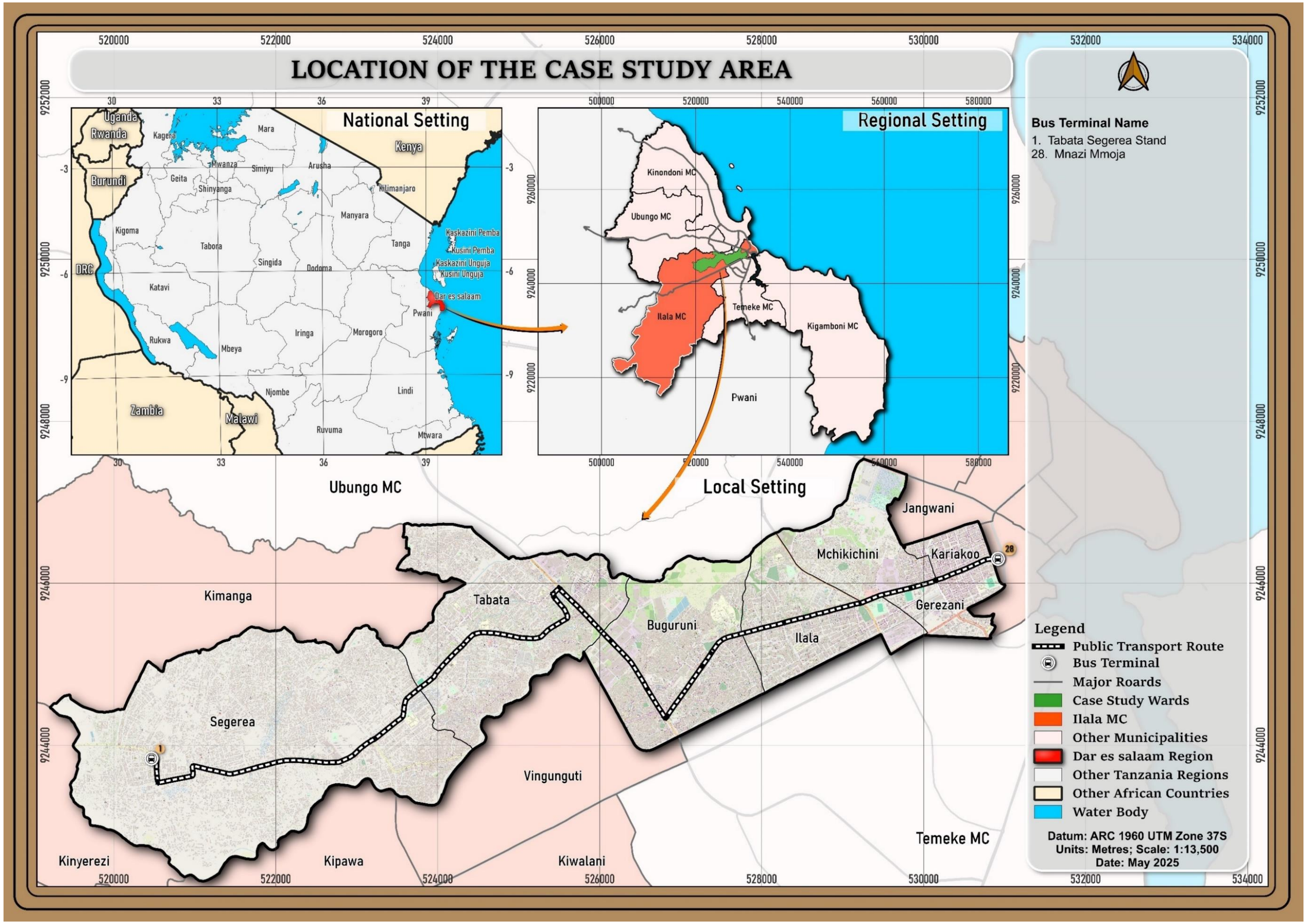
The proposed area of study is the Mnazi mmoja-Tabata Segerea route (via Uhuru road); the selection of such a route is based on several criteria, namely, the presence of Commuter Bus Transport (CBT) route, high passenger volume, diverse bus stops, absence of bus rapid transit (BRT) infrastructure, critical congestion hotspots, data availability/access, logistical feasibility for research, socioeconomic importance, opportunity for stakeholder engagement and potential for scalable solutions.

The Mnazi mmoja-Tabata Segerea route meets all the criteria, making it a suitable study area for this research.

TABLE 1 Criteria for selection of study area

Criteria	**Posta-Simu2000 CBT Route (Via Morogoro road)**	**Kimara mwisho–Kivukoni CBT Route**	**Posta-Mbagala rangi 3 CBT Route**	**Mnazi mmoja-Tabata Segerea CBT Route (Via Uhuru road)**
High Passenger Volume	✔	✔	✔	✔
Diverse Bus Stops	✔	✔	✔	✔
Absence of BRT Infrastructure	✗	✗	✗	✔
Key Congestion Hotspot	✗	✔	✔	✔
Data Availability/Access	✔	✔	✔	✔
Logistical Feasibility for Research	✔	✗	✗	✔
Socioeconomic Importance	✔	✔	✔	✔
Potential for Scalable Solutions	✔	✔	✔	✔

Source; Author (2025)



MAP 1: Location of the Study Area

Source: Author (2025)

4.5 The Units of analysis

The fact that this study embodies a mixed-methods approach means that multiple levels of analysis were also adopted. According to Yin (2018), the unit of analysis (a case) may not be based on a single person (e.g., interviews with people). Instead, it may be the organization, community, or social groups from which a social studies researcher collects data in relation to the framing of the initial research questions to comprehensively address the research problem. In the context of alleviation of passenger overcrowding at bus stops, a number of key units of analysis becomes relevant to my study:

4.5.1 Primary Unit of Analysis:

The primary unit of analysis is Passengers at Bus Stops; Since the study focuses on passenger overcrowding, individual passengers are the core unit. Their behaviors, waiting times, travel patterns, and responses to intelligent mobility solutions (e.g., real-time passenger information systems) was crucial for analysis.

4.5.2 Secondary Units of Analysis:

On the other hand, the secondary units of analysis for this study included bus stops as well as public transport vehicles, which in this case are the daladalas. Bus stops serve as key spatial units where passenger congestion occurs, making them critical for analysis. Various factors, including passenger volume, infrastructure design, location characteristics, and the availability of intelligent mobility solutions, will be examined to understand their impact on overcrowding. Moreover, public transport vehicles play a significant role in shaping congestion dynamics. Their frequency, capacity, and scheduling directly influence passenger flow at bus stops, affecting waiting times and overall service efficiency. By analyzing both bus stops and transport vehicles, the study aims to provide a comprehensive understanding of the factors contributing to passenger overcrowding and how intelligent mobility solutions can address these challenges.

4.6 Sample Size and Sampling Procedures

The sample size for this study was determined based on the need to capture diverse perspectives from passengers, transport operators, and policymakers. A combination of probability and non-probability sampling techniques was used to ensure a representative sample while allowing flexibility in qualitative data collection.

4.6.1 Sample Size Determination

A statistically significant sample size was calculated using the Cochran formula to ensure reliable generalizations for quantitative data. The sample included passengers across the selected commuter bus corridor (in the respective bus stops) in Tanzania, selected based on peak congestion periods and passenger volume. According to the interview conducted with LATRA's regional in-charge officer, there is no traffic survey that has been done to determine the volume of passengers across the Mnazi Mmoja – Tabata Segerea route, the same goes for all other commuter-bus routes in Dar es Salaam. In that light, Corchan's formula was used to identify the ideal sample size that best fits an infinite population

In this case, from Corchan formula;

$$n = \frac{Z^2 \cdot p \cdot (1-p)}{E^2}$$

(Source; Kothari, 2018)

n = 384

Where:

n = required sample size for an infinite population

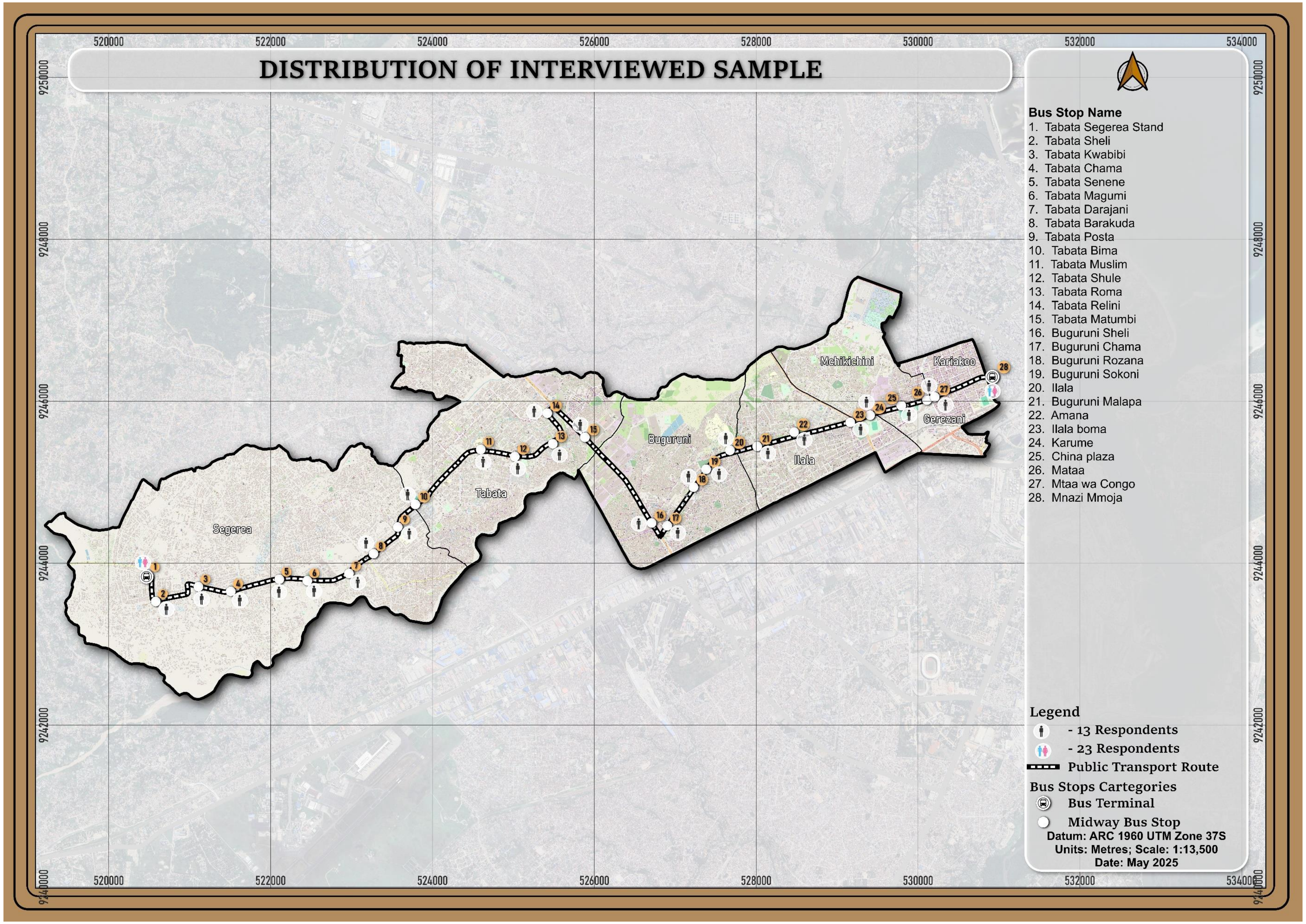
Z = Z-score (1.96 for 95% confidence level)

P = Estimated proportion of the population (0.5, as the most conservative estimate)

E = Margin of error (0.05 or 5%)

The final required sample size (n') is, therefore, **384 passengers**

The 384 sample was further subdivided across the 26 commuter bus stops and 2 bus stands located within the selected bus route, where 13 respondents were interviewed at each bus stop and 23 respondents were interviewed at each of the two bus stands located at both ends of the selected route.



MAP 2 Distribution of Interviewed sample. Source: Author, 2025

For qualitative data, purposive sampling was employed to select key stakeholders, including transport authorities, bus operators, and urban planners. The sample size for qualitative interviews and followed data saturation principles, where new data no longer provides additional insights.

4.6.2 Sampling Procedures

In this study, four key sampling techniques were employed: Stratified Random Sampling, Purposive Sampling, Systematic Sampling, and Snowball Sampling. Each method served a specific purpose in ensuring that the data collected is representative, reliable, and insightful for understanding commuter bus overcrowding in Dar es Salaam. Below is a detailed discussion of these methods, their theoretical foundation, and how they will be applied in the study.

i. Stratified Random Sampling;

Stratified random sampling is a probability sampling method where the population is divided into distinct subgroups, or strata, based on specific characteristics. A random sample is then drawn from each stratum to ensure that all relevant groups are adequately represented (Kothari, 2004). This method minimizes bias and improves the accuracy of findings by ensuring that different segments of the population are proportionally included in the study.

In the context of this research, stratified random sampling was applied to select passengers from different bus stops. The strata were determined based on factors such as the level of congestion at bus stops, peak and off-peak travel periods, and demographic characteristics such as age and gender. By doing so, the study captured diverse travel patterns and experiences related to overcrowding, allowing for a more comprehensive understanding of passenger behaviors and challenges.

ii. Purposive Sampling

Purposive sampling, also known as judgmental sampling, is a non-probability technique where participants are selected based on their expertise, role, or direct involvement in the subject matter (Kothari, 2004). This method is particularly useful when researcher needed insights from key stakeholders who possess specialized knowledge or experience relevant to the study.

For this study, purposive sampling was used to select transport officials, policymakers, and technology providers involved in urban mobility management. Participants included Transport officials from LATRA (Land Transport Regulatory Authority) and Regional Transport Engineers from Tanzania National Roads Agency (TANROADS) . Their perspectives provided valuable insights into policy enforcement, regulatory challenges, and possible technological solutions for improving the efficiency of commuter bus operations in Tanzania.

iii. Systematic Sampling

Systematic sampling is a probability sampling technique where participants are selected at regular intervals from a predefined list or population (Kothari, 2004). This method is effective for obtaining a representative sample without the complexity of purely random selection, ensuring a more structured data collection process.

In this study, systematic sampling was used to monitor passenger flow and congestion levels at bus stops. Observers recorded data on every 5th commuter arriving at a bus stop to track movement patterns, waiting times, and boarding behaviors. This approach will provide quantitative evidence of overcrowding trends at different times of the day and across various locations. By applying systematic sampling, the study ensured that observations are evenly distributed and unbiased, thereby improving the reliability of findings related to passenger congestion.

iv. Snowball Sampling

Snowball sampling is a non-probability technique where initial respondents refer other participants with similar experiences, creating a chain of respondents (Kothari, 2004). This method is particularly effective for reaching hard-to-access groups who may not be easily identified through traditional sampling techniques.

In this study, snowball sampling was applied in qualitative interviews with daladala drivers, conductors and commuters. Since these individuals experience overcrowding firsthand, they can provide detailed personal accounts of the challenges they face, such as long waiting times, operational inefficiencies, and safety concerns.

By employing a combination of stratified random sampling, purposive sampling, systematic sampling, and snowball sampling, this study ensures that data collection is both quantitatively rigorous and qualitatively insightful. Each method is tailored to a specific research objective, whereby Stratified random sampling ensures the inclusion of diverse passenger groups, Purposive sampling targets key transport stakeholders for expert opinions, Systematic sampling provides structured data on congestion trends, and Snowball sampling captures in-depth experiences from transport operators and commuters.

Together, these sampling techniques enabled the study to provide a comprehensive and well-balanced analysis of commuter bus overcrowding in Dar es Salaam, supporting informed decision-making for improving public transport services.

TABLE 2 Summary of the study participants

S/no	Participant group	Estimated Sample size	Data collection method
01	Passengers at bus stops	384	Structured surveys and observations
02	Commuter Bus drivers	61	Structured interviews
03	Urban Planner	1	Key informant interviews
04	Public Transport Regulators (LATRA)	1	Key informant interviews
05	Road Infrastructure Manager (TANROADS)	1	Key informant interviews

Source: Author, 2025

4.7 Data Collection Methods and Techniques

The data collection process for this study employed mixed-methods approach; this kind of an approach integrates both quantitative and qualitative techniques. This approach ensured deep understanding of how intelligent mobility solutions can alleviate passenger overcrowding at bus stops. The selected methods focused on identifying numerical trends regarding overcrowding and stakeholder perspectives, providing room for in-depth problem analysis.

4.7.1 Quantitative Data Collection Methods

Quantitative data was be collected to analyze passenger flows, congestion patterns, and the effectiveness of mobility solutions at bus stops. The key methods included structured surveys, observational studies, and system data analysis

Structured surveys was conducted amongst 384 passengers at 28 bus stops located along the Mnazi mmoja – Tabata Segerea route. These surveys captured passenger boarding times, waiting durations, perceived congestion levels, and awareness of intelligent mobility solutions. Questionnaires developed through KoboToolbox and stored in the ODK program was used to ensure standardized responses for easier analysis.

In addition to surveys, observational studies were be carried out to record real-time congestion levels, queue formations, waiting times, and boarding efficiency at bus stops. This involved manual passenger counts during peak and off-peak hours, on-site observations and monitoring to aid the researcher in analyzing movement patterns, and an assessment of bus stop infrastructure and its role in overcrowding.

4.7.2 Qualitative Data Collection Methods

To complement the numerical data, qualitative methods provided deeper insights into the causes of bus stop overcrowding and potential solutions. Such methods included structured interviews and Key Informant Interviews (KIIs).

Structured interviews were conducted with key stakeholders, including 55 intended public transport drivers, 1 transport regulator, 1 urban planner, and 1 Transport Engineer. These interviews explored operational challenges, congestion management strategies, policy interventions, and infrastructure limitations.

Additionally, key informant interviews (KIIs) were held with senior officials in the transport sector to gain expert insights on strategic urban mobility planning, potential technology-based interventions, and regulatory challenges. These interviews provided high-level perspectives that were crucial for policy recommendations.

4.7.3 Data Collection Tools

To ensure data reliability and accuracy, various data collection tools were used, including structured questionnaires for surveys, observation checklists for congestion monitoring, interview guides for structured discussions, and GPS & GIS tools for geospatial analysis of high-traffic bus stops. The table below summarizes the application of these tools.

TABLE 3 Summary of tools to be used in data collection

Tool	**Purpose**	**Application**
-Structured Questionnaires installed in ODK Application -Camera -Notebook	Collect passenger experiences and preferences	Administered at bus stops via ODK installed forms
Observation Checklists	Monitor congestion patterns, waiting times	Field researchers record real-time data
Interview Checklist	Gather insights from key stakeholders	Used for structured interviews

GPS & GIS software	Analyze passenger movement and bus stop efficiency	For geospatial mapping of high-traffic stops

Source: Author, 2025

4.7.4 Ethical Considerations

All data collection processes adhered to ethical research principles to ensure that participants' rights are protected. Informed consent was obtained from all participants before data collection, and they were fully briefed about the study’s objectives. Confidentiality was maintained, ensuring that responses remain anonymous and personal identifiers are, unless approved by respondents, not disclosed. Additionally, the study complied with local data protection laws and obtained necessary research permits to ensure that ethical standards are upheld throughout the research process.

4.8 Data Analysis

This study employed multiple data collection tools, including ODK (Open Data Kit) surveys, field observations, stakeholder interviews, and GIS-based spatial analysis. Each of these tools generated data that was systematically analyzed to extract meaningful insights into passenger congestion, waiting times, and commuter behavior patterns. The analysis process for each method is detailed below.

Structured Questionnaires (ODK Application);

The structured questionnaires administered through the ODK application aided in collecting quantitative data on passenger experiences, waiting times, overcrowding levels, and service satisfaction. Since ODK captures responses digitally, the data will be exported to the statistical software Excel for processing and analysis.

Descriptive statistics were applied to summarize key passenger concerns, including average waiting time, peak congestion hours, and service satisfaction levels. Comparative analysis was conducted across different bus stops, time periods, and passenger demographics to highlight congestion and waiting times variations.

To examine relationships between different variables, cross-tabulations and correlation analysis will be employed. For example, the study assessed whether specific bus routes experience higher overcrowding than others. the findings are visually represented through maps for more straightforward interpretation.

Observation Checklists;

Field researcher used observation checklists to record real-time congestion levels, waiting times, and passenger boarding behaviors at bus stops. These checklists provided objective, non-biased data on commuter flow patterns and overcrowding conditions.

Observation data was compiled and entered into spreadsheets for structured analysis. Trends in waiting times and crowding levels will be analyzed using time-series analysis, allowing for the identification of peak congestion periods throughout the day. Data from different bus stops and time slots was then compared to determine which locations experience the highest passenger volumes and longest wait times.

Interviews with Key Stakeholders;

Interviews with transport engineers from TANROADS, commuter bus drivers, urban planners, and the Transport Regulatory Authority (LATRA) provided qualitative insights into the operational challenges and regulatory issues affecting commuter bus services. The interview data were transcribed and analyzed using thematic analysis, where responses were categorized into key themes such as policy enforcement, operational inefficiencies, infrastructure gaps, and proposed solutions.

Content analysis was conducted to identify recurring patterns and concerns raised by different stakeholders. By comparing perspectives from transport regulators, bus drivers, and commuters, the study highlighted areas of policy misalignment and operational shortcomings.

Qualitative data analysis, thematic analysis was used to manage and code large volumes of text data. The results were summarized in narrative form, supported by direct quotes from respondents to illustrate key points. Interview findings complemented the statistical data, providing a deeper understanding of the causes and consequences of overcrowding.

GPS & GIS Software;

GPS and GIS software were used to analyze passenger movement patterns, bus stop efficiency, and spatial congestion trends. The GPS data collected from transit nodes was overlaid onto GIS maps and visually represented high-traffic areas and congestion hotspots.

Using spatial density analysis, the study identified which bus stops experience the highest levels of passenger congestion. This was helpful in assessing whether the current distribution of bus stops aligns with passenger demand. GIS mapping was used to evaluate route efficiency and accessibility, determining areas that require additional bus services or route modifications.

The integration of GIS data with passenger survey responses allowed for a comparative analysis between reported commuter experiences and real-time spatial congestion patterns. This ensured that policy recommendations are based on both subjective passenger feedback and objective geospatial data.

By integrating data from ODK questionnaires, field observations, stakeholder interviews, and GIS mapping, the study comprehensively analyzed commuter bus congestion in Dar es Salaam. The ODK data offered quantitative insights into passenger experiences, while observations provided real-time congestion assessments. Stakeholder interviews highlighted policy and operational challenges, and GIS analysis mapped out spatial trends in passenger overcrowding hotspots.

This multi-method approach ensured that the study captures both numerical trends and lived experiences, leading to data-driven recommendations for improving commuter bus operations and reducing overcrowding at bus stops.

4.8.1 Quantitative Data Analysis

The quantitative data collected from structured surveys, observational studies, and system data analysis was analyzed using statistical and geospatial techniques. The key steps in quantitative data analysis included:

1. Data Cleaning and Preparation

Before analysis, the collected data was checked for completeness, consistency, and errors. Data cleaning techniques, such as removing incomplete entries and standardizing responses, addressed any missing or inconsistent responses. The cleaned data was then coded for statistical processing.

2. Descriptive Statistics

Descriptive statistical methods were used to summarize key trends, including: Passenger volume at bus stops (boarding, waiting, and alighting patterns), Peak and off-peak congestion levels at selected bus stops, Passenger waiting times and their variation across different times of the day, Public transport frequency and its impact on congestion.

The analysis includes measures such as percentages and thematic mapping to describe the characteristics of congestion and mobility patterns. Data visualization tools such as bar charts, histograms, and pie charts were used to present key findings.

3. Geospatial Analysis

To understand the spatial distribution of congestion hotspots, GIS (Geographic Information Systems) was used to map high-traffic bus stops and analyze spatial patterns of overcrowding. This involved: Mapping passenger waiting times at selected bus stops, Identification of congestion-prone areas based on observed passenger behavior, Evaluating the impact of bus stop location, surrounding land use, and infrastructure on overcrowding.

GIS-based geospatial analysis provided visual representations of congestion trends, supporting data-driven recommendations for intervention strategies.

4.8.2 Qualitative Data Analysis

The qualitative data collected from structured interviews and key informant interviews (KIIs) was analyzed using thematic analysis to extract key insights. The analysis followed these steps:

1. Transcription and Data Organization

All recorded interviews and discussions were transcribed verbatim to ensure accuracy. The transcripts were categorized based on participant groups (drivers, operators, regulators and Engineers) for a structured analysis.

2. Coding and Thematic Analysis

The transcribed data was analyzed using a coding process where key themes and patterns related to bus stop congestion and mobility solutions were identified. Some anticipated themes include: Passenger experiences with overcrowding, Challenges faced by drivers and transport operators in managing congestion, Effectiveness of existing mobility solutions and areas for improvement, and Policy and infrastructure challenges contributing to bus stop congestion.

Thematic coding was performed using manual qualitative analysis techniques, ensuring that the findings are systematically categorized and interpreted.

3. Triangulation for Validation

To enhance the reliability of the findings, triangulation was necessary to compare qualitative insights with quantitative results. For example, interview responses about congestion levels was cross-checked with observational and survey data to ensure validation and consistency.

4.8.3 Integration of Quantitative and Qualitative Findings

Since this study employed a mixed-methods approach, findings from both quantitative and qualitative analyses were integrated for a comprehensive interpretation. The integration compared statistical trends (e.g., passenger congestion levels) with qualitative explanations (e.g., drivers' experiences in handling overcrowding), validated numerical data with insights from transport professionals and policymakers, and enhanced policy recommendations by incorporating both data-driven and experience-based evidence.

4.8.4 Demographic Profile of Respondents (Passengers)

Understanding the demographic characteristics of respondents is essential for contextualizing the findings of this study, particularly in relation to travel behavior, technology adoption, and perspectives on passenger overcrowding. The study engaged three primary categories of respondents: commuter bus passengers, commuter bus drivers, and key institutional stakeholders drawn from LATRA, TANROADS, and the Urban Planning Department of Ilala Municipality.

This diverse composition provided a comprehensive, multi-perspective view of the challenges and opportunities surrounding bus stop decongestion in Dar es Salaam

TABLE 4 Key research issues and respective methods used in data collection

Research Objectives	Methods				
	Literature review	Key Informant Interviews	Questionnaire Surveys	Observations	Photographic registration
Identification of key factors contributing to overcrowding at bus stops, considering infrastructure, operational, and behavioral aspects.	✓	✓	✓	✓	▪
Assessment of the role of intelligent mobility solutions and institutional frameworks in addressing passenger congestion.	✓	✓	▪		
Exploration of passenger behavior and adaptability in response to intelligent-based mobility interventions for alleviation of passenger overcrowding	▪	✓	✓	▪	
Assessing the effectiveness of various intelligent mobility solutions in reducing passenger overcrowding and improving bus stop operations.	✓	✓	▪		

Key

- ✓ Represents an Important method
- ▪ Represents a complementary method

4.8.5 Ethical Considerations in Data Analysis

Throughout the analysis process, ethical considerations were maintained to ensure data integrity and confidentiality. During surveys, respondents were initially asked for their consent, the data gathered throughout the survey (Both primary and secondary data) was securely stored and analyzed only for academic purposes. Personal identifiers were removed from transcripts and survey data to maintain participant privacy. Additionally, the findings were reported objectively, ensuring that interpretations remain unbiased and supported by evidence.

5. PASSENGER OVERCROWDING AT BUS STOPS

5.1 Introduction

The previous chapter discussed the process used to guide the execution of this research, this chapter therefore, presents the findings derived from the fieldwork conducted through processes discussed in the previous chapter in order to explore the role of intelligent mobility solutions in alleviating passenger overcrowding at commuter bus stops in Dar es Salaam, Tanzania. These findings offer a crucial way of assessing the current status of intelligent mobility adoption with respect to commuter bus stops operation, The findings are also insightful in identifying the gaps in scope of usage and/or adoptability of intelligent mobility solutions that can best address the issue of passenger overcrowding at bus stops. The findings are systematically organized to address the research objectives as discussed in Chapter One and are interpreted in relation to the conceptual and theoretical frameworks outlined in Chapter Three, all through the methodology as discussed and interpreted in Chapter Four.

To generate robust and triangulated insights, the findings from this chapter (Five) through to chapter Eight are presented in a thematic structure that mirrors the specific objectives of the study. Each chapter synthesizes evidence across respondent groups, documented field observations and then go through a lens of established set of theories and concepts to offer an integrated understanding of the issue.

Furthermore, the analysis is closely aligned with the conceptual framework developed in Chapter Three, which conceptualizes passenger overcrowding as an outcome of interrelated infrastructural, behavioral, operational, and technological variables. The framework draws on several theoretical lenses, including the Activity-Based Travel Demand Theory, Systems Theory, and the Technology Acceptance Model (TAM). These models offer a multidimensional lens through which the empirical data are interpreted, examining not only the structural causes of congestion but also user acceptance of innovations and institutional readiness for smart mobility integration.

In essence, these chapters (Five to Eight) translate raw data into structured knowledge, establishing the empirical basis for the discussions and reflections in Chapter Nine and conclusions, and recommendations in Chapter Ten. The thematic flow ensures that the findings not only respond to the research questions but also validate and refine the conceptual assumptions underpinning the study.

5.1.2 Passenger Respondents

A total of 384 passengers were surveyed across 26 commuter bus and two bus stands located along the selected Commuter bus route. The respondents represented a broad age spectrum, with the majority falling between the ages of 20 and 40 years, reflecting the city's active working population.

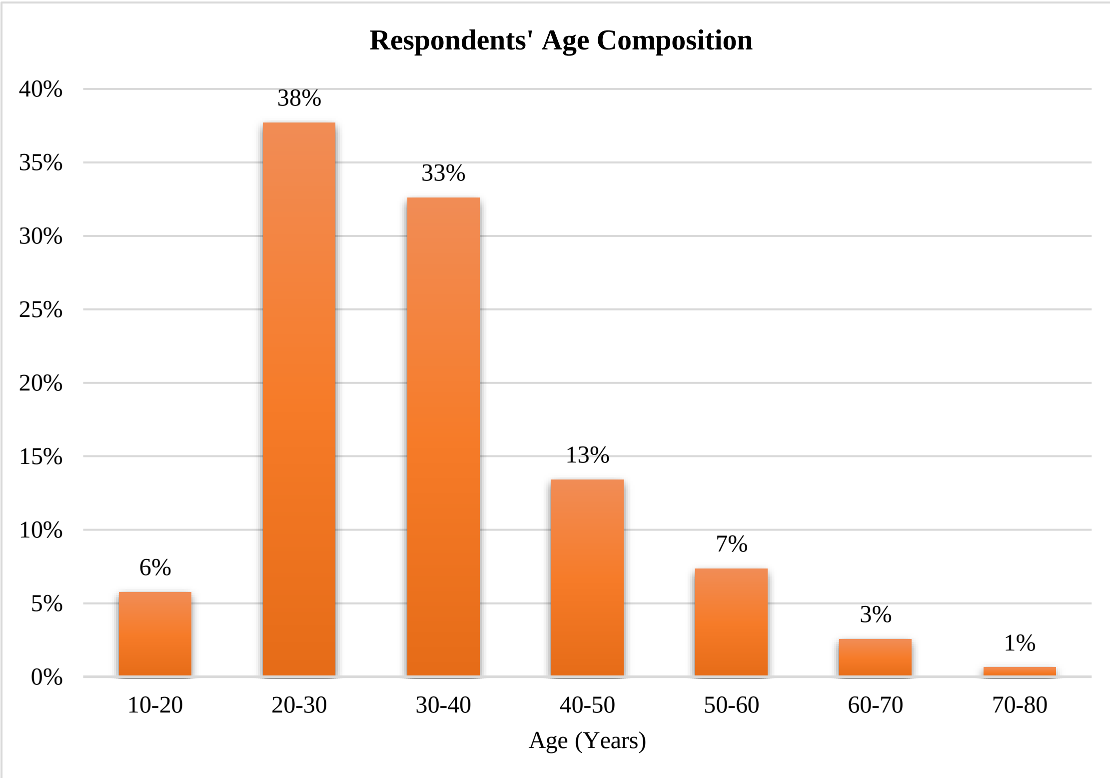


FIGURE 3 Age composition of the interviewed sample (Passengers)

Source: Author 2025

Both genders were adequately represented, with 57% male and 43% female participants. Most respondents indicated frequent use of public transport, with 54% reporting daily commuting via daladalas or BRT buses. This high reliance on public transport underscores the critical importance of efficient commuter systems and the urgency of addressing overcrowding at bus stops.

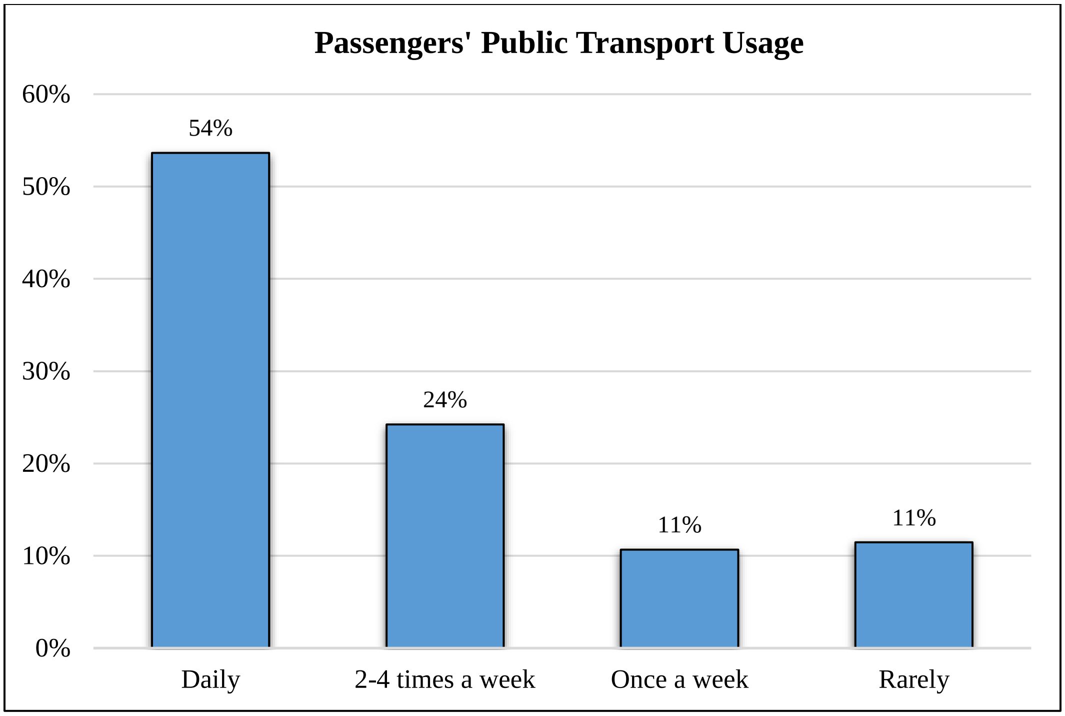


FIGURE 4 Frequency of commuter bus transport usage by passengers

Source: Author, 2025

In terms of information access and mobility behavior, the respondents exhibited varied levels of digital literacy. While a considerable proportion had access to smartphones, usage of transport-related applications remained low, suggesting potential barriers to the adoption of intelligent mobility solutions. These demographic insights are pivotal in assessing the feasibility and user acceptance of intelligent and innovative interventions.

5.1.3 Driver Respondents

The driver survey involved 55 commuter bus drivers as opposed to 61 commuter bus drivers who were sampled for survey, this was due to a fact that the number of busses operating in the selected route during the period of data collection could not exceed 55 busses, and that since the sample size of 61 busses was not met, all of the available bus drivers (55) had to be interviewed to get the most out of the available sample. The survey of these drivers revealed that 42% of drivers have extensive experience of driving these buses (over 10 years), while 37% have a fair driving experience of about 5 to 10 years, and 21% of these drivers are relatively unexperienced, with less than 5 years of operating public busses. Overall, their daily interactions with passengers and repeated exposure to peak-hour dynamics made them critical informants in understanding operational challenges and behavioral trends at bus stops.

Drivers overwhelmingly identified early mornings (5:00 AM – 9:00 AM) and evenings (4:00 PM – 8:00 PM) as peak congestion periods. As quoted by some of the drivers;

> *" ..We normally make most of our earnings in early mornings and evening as a result of high number of passengers in such time periods..". "..On average, we usually spend very few minutes at bus stops to pick up passengers in the morning and evening compared to mid-day times where a bus can wait for passengers at one bus stop for up to 10 minutes or more…" "…I'd rather drive my bus early in the morning, take a break in the afternoon and again, get back to work in the evening, this routine can help in fuel savings in some days…"*

They also highlighted significant stressors such as pressure from passengers to overload buses, limited stopping space, and the absence of real-time scheduling mechanisms. A smaller portion of drivers had prior exposure to intelligent mobility systems; primarily through informal tools such vehicle tracking devices such as GPS.

5.1.4 Key Informants (Institutional Stakeholders)

In-depth interviews were conducted with urban transport officials from LATRA, TANROADS, and Ilala Municipality. These respondents included senior In-charge officers and technical planners responsible for regulatory oversight, infrastructure development, and urban mobility planning. Their institutional roles provided critical insights into policy frameworks, regulatory constraints, implementation bottlenecks, and strategic visions for intelligent mobility in Dar es Salaam.

While these officials were generally familiar with the concepts of intelligent mobility and real-time systems, they acknowledged a range of barriers to implementation, including infrastructural limitations, budgetary constraints, fragmented stakeholder coordination, and insufficient public awareness. Their perspectives provide the necessary institutional lens through which the survey findings are interpreted in later sections.

The demographic profiles of respondents establish a strong foundation for understanding the multidimensional nature of passenger congestion at bus stops. The diversity in age, occupation, technological exposure, and operational experience enables a balanced analysis that incorporates both commuter behavior and systemic constraints. These profiles are instrumental in evaluating the applicability and scalability of intelligent mobility solutions in the unique socio-economic and infrastructural context of Dar es Salaam.

5.2 Overcrowding Trends at Bus Stops

Passenger overcrowding at commuter bus stops in Dar es Salaam remains a persistent and systemic issue that undermines the efficiency, safety, and user experience of public transport systems. This section presents empirical findings related to the first research objective that seeks 'To identify the key factors contributing to overcrowding at bus stops. The data presented here are derived from passenger surveys, driver surveys, feedback from key informants, as well as documented field observations, and are then interpreted in light of the broader urban transport environment through available literature as well as a set of guiding theories and principles as discussed in the theoretical and conceptual framework.

5.2.1 Overcrowding from Passengers' Perspective

Majority of surveyed passengers (72%) are practically aware of passenger overcrowding at bus stops, having acknowledged that they are well aware of and have frequently experienced overcrowding at commuter bus stops particularly during peak travel hours. Most of interviewed passengers described the severity of overcrowding as a source of prolonged waiting times, physical discomfort, and heightened exposure to traffic-related hazards, and as observed by the researcher, These experiences are particularly acute at major transit points such as Mnazimmoja, Ilala Boma, Buguruni, Tabata bima and among others Tabata Segerea bus stand.

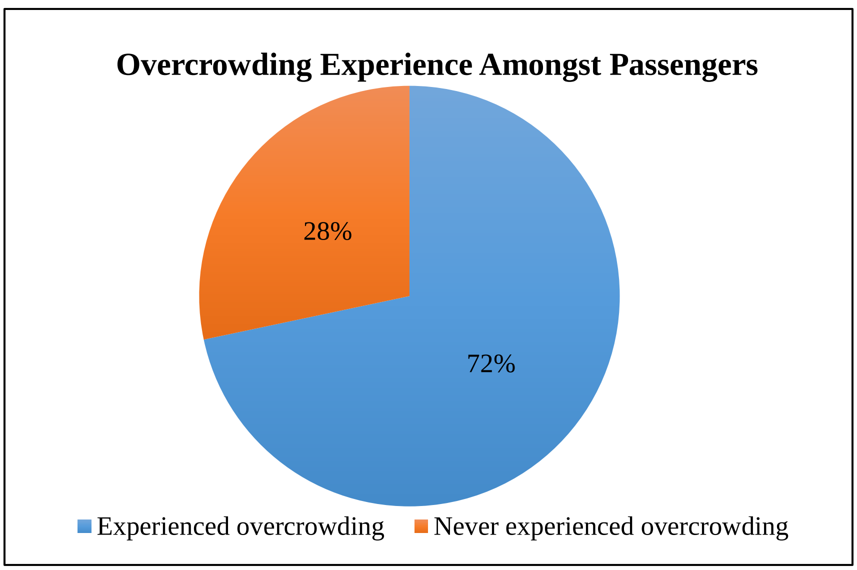


FIGURE 5 Overcrowding experience amongst passengers

Source: Author, 2025

When asked about the underlying causes of these overcrowding, passengers cited a combination of infrastructural and operational inefficiencies. The most frequently mentioned cause was high passenger demand, especially during peak commuting hours, driven by the city's expanding population and concentrated economic zones. However, the demand pressure was exacerbated by other systemic weaknesses:

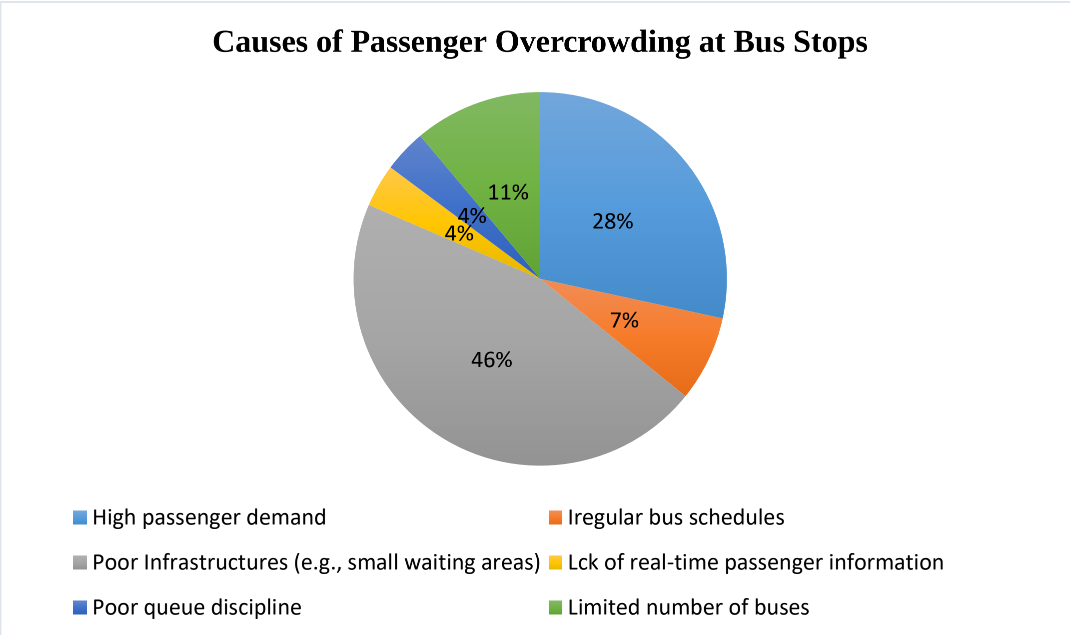


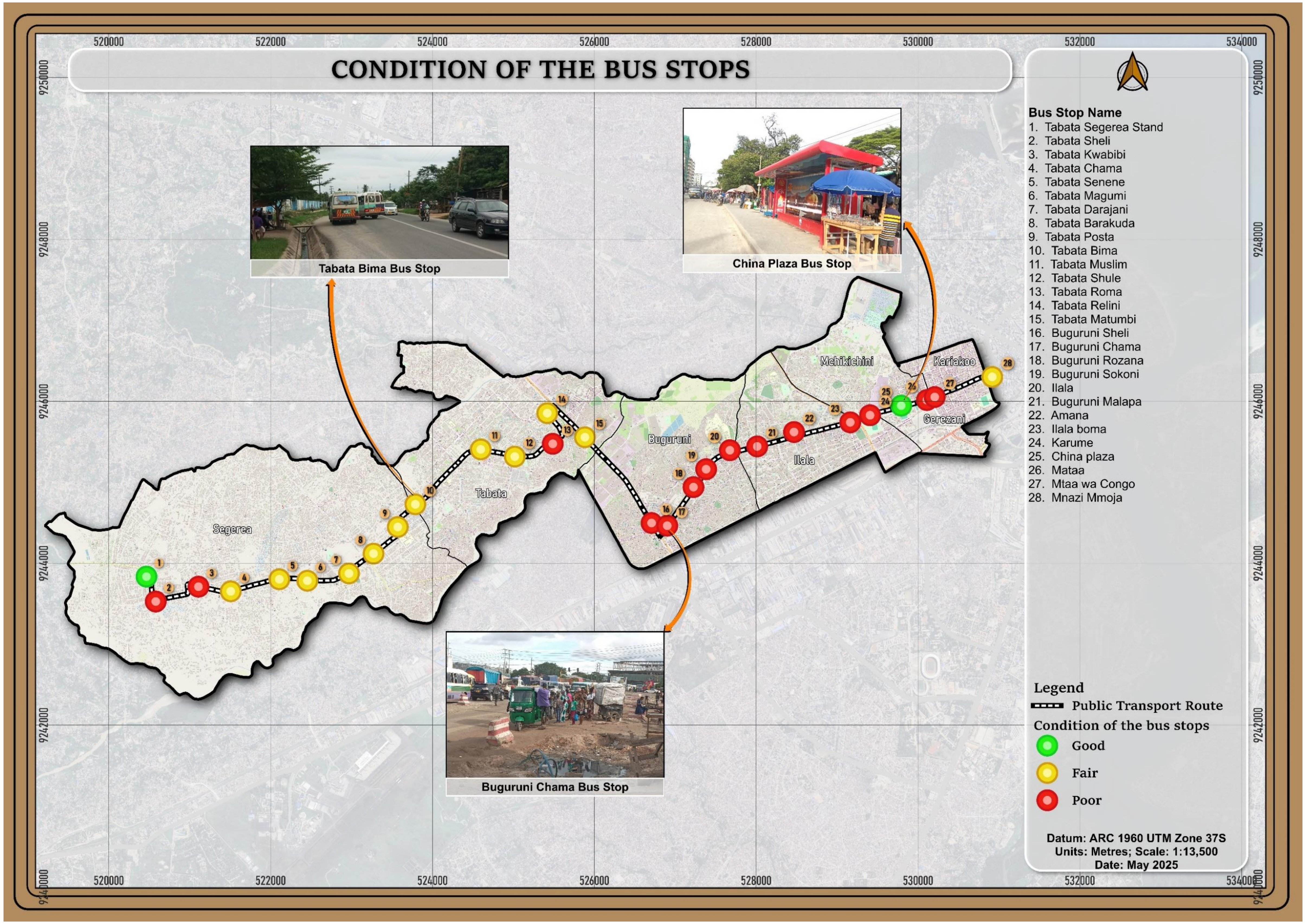
FIGURE 6 Causes of passenger overcrowding at commuter bus stops

Source: Author 2025

While Poor infrastructure was highlighted as a major contributor to passenger overcrowding at commuter bus stops, the same was visually observed on the ground during physical observation of the condition of the bus stops, which was later on visualized (See Map 3), The condition of the bus stops was cartegorized on the basis of the following criteria.

TABLE 5 Criteria for Assessment of Bus Stop Condition

Bus Stop Condition	Criteria (Available Amenities)
Good	Bus stopping island Sitting Bench(es) Paved boarding area/island Supporting signs and markings (eg. Bus stop sign/markings etc)
Fair	Bus stoping island Paved boarding area/island
Poor	Lacks all/ most of the above amenities



MAP 3: Condition of the Bus Stops Located along the Studied Corridor

Source: Author, 2025

Other hindrances, such as High passenger demand and a Limited number of operational buses, emerged as immediate challenges subsequently.

On the other hand, Irregular bus schedules, Lack of intelligent solutions, and poor queue discipline were other recurring themes. The responses given by passengers align with observations made during the field survey, where it was observed that many of the bus stops do not offer adequate space or amenities to safely accommodate the volume of passengers they receive. Figure 7 was recorded from one of the bus stops located within the study area, It clearly depicts this reality where passengers are appearing scattered on the designated bus stop that does not have supportive infrastructure amenities such as seating benches, dedicated area for commuter busses to stop, the area also appears to have no shading area for waiting passengers.

FIGURE 7 Infrastructure Inadequacy recorded at Ilala-boma bus stop

Source: Author 2025

On the other hand, irregular bus schedules, and Poor queuing discipline were highlighted as a major contributor of passenger overcrowding, with passengers expressing frustration over the unpredictability of vehicle arrivals, and the mechanism through which they board and/or drop from the buses. This irregularity often results in multiple passengers clustering at stops simultaneously, leading to overcrowding surges.

FIGURE 8 Poor queuing discipline demonstrated at Msimbazi bus stop

Source: Author, 2025

These findings suggest that while demand is a structural factor linked to urban growth and commuter dependency on public transport, the intensity of overcrowding is amplified by deficiencies in Intelligent mobility solutions such as RTPI, and the lack of regulated boarding practices such as allocation of specialized cueing lines. The implications of this are multifaceted: not only does overcrowding reduce commuter satisfaction, but it also contributes to inefficiencies in the transport network by delaying loading times and increasing turnaround intervals.

5.2.2 Overcrowding from Drivers' Perspective

The views of commuter bus drivers further substantiate the extent and complexity of the passenger-overcrowding problem. According to the responses given by the 55 commuter bus drivers during field survey, all of them, which is an equivalent of 100% pointed out that they normally encounter passenger overcrowding consistently during peak hours, describing it as an unavoidable operational norm. These drivers identified early mornings (5:00 AM–9:00 AM) and evenings (4:00 PM–8:00 PM) as the periods of highest strain, corresponding with working-hour flows.

key operational challenges that result to passenger overcrowding as raised by the bus drivers were inadequacy of the existing fleet size to meet peak-hour demand, which was raised by 29% of the interviewed drivers, as well as an Inadequate number of bus stops and their supportive infrastructure, which was also highlighted by 29% of the interviewed drivers. Other Challengers such as Irregular bus schedules (14%), High Passenger demand (13%) and Lack of real time passenger information system (11%) , reasons other than those mentioned took 4%.

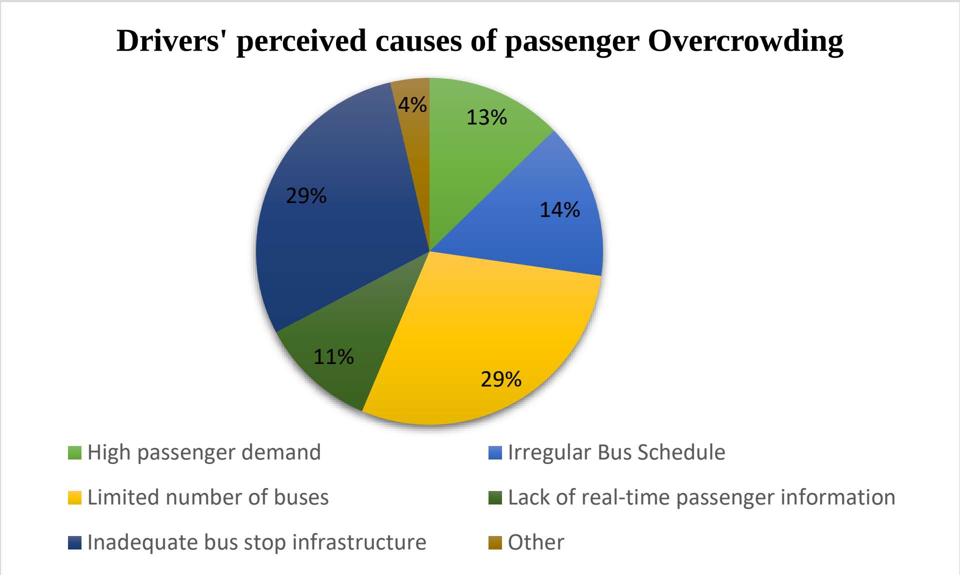


FIGURE 9 Drivers' perceived causes of passenger overcrowding

Source: Author, 2025

From such figures, it is clear that leveraging Intelligent Mobility Solutions, which is the focal point of this study, can potentially address about 25% of the stated overcrowding causes, namely, the absence of RTPI (11%) and, among others, Irregular bus schedules (14%), this is due to the fact that, establishment of innovative solutions such as Vehicle Tracking Systems, Real Time Passenger Information System, and among others, smart ticketing can easily regularize bus schedules and guide passengers appropriately on when to arrive and board their busses without having to wait for too long.

FIGURE 10 Overloaded bus recorded at Buguruni-Sokoni bus stop

Source: Author, 2025

Another major constraint relating to infrastructure and design flaws at bus stops as identified by the drivers include limited size of stopping areas, poor road conditions near loading areas, and a lack of dedicated pick-up zones. As quoted by one of the Bus drivers;

> *"The city's population has grown, new bus stops should be established within the existing transport corridors, there are several informal areas where we pick up and drop off passengers as we commute, which results to frequent bus stopping, and as a result, it takes much longer to arrive at the designated bus stops"*

These constraints hinder smooth passenger boarding and disembarkation, extending dwell times and increasing delays for subsequent buses. The lack of coordination among buses, especially at high-traffic stops, further compounds the issue. Without a centralized scheduling system or real-time communication between buses, arrival clustering and bottlenecks are common.

The drivers' perspective therefore, reveals that overcrowding is not merely a result of excessive passenger numbers but is deeply tied to operational inefficiencies, infrastructural limitations, and the absence of supportive technological systems. These findings align with the Systems Theory component of the study's conceptual framework, which emphasizes the interdependence of transport components, passengers, operators, infrastructure, and policy. They also underscore the urgent need for an integrated response involving both hardware (infrastructure, fleet) and software (Intelligent transport solutions).

5.2.3 Institutional Views on Passengers' Overcrowding

Institutional stakeholders, including officials from the Tanzania National Roads Agency (TANROADS) and the Urban Planning Department of Dar es Salaam city, provided critical perspectives that illuminate the structural and policy-level factors underpinning passenger overcrowding at commuter bus stops in Dar es Salaam. Their views emphasize the inadequacy of existing infrastructure and urban design systems in addressing the current demands of urban mobility.

Infrastructure Gaps (TANROADS Perspective)

TANROADS highlighted a persistent misalignment between road infrastructure planning and the operational needs of public transport systems. According to responses drawn from the TANROADS planning engineer, there is a chronic lack of dedicated bus bays, shelters, and sufficient pedestrian space at many commuter bus stops across the city. Current road designs often prioritize vehicle throughput over public transport staging, which results in buses stopping directly on traffic lanes, thereby disrupting flow and creating unsafe conditions for boarding and alighting passengers. To cater for this challenge, TANROADS proposed a BRT network, which would operate in an exclusive lane.

Moreover, officials acknowledged that most commuter bus stops are inherited from an outdated master plan (of 1976-2006), failing to accommodate the scale of urbanization and daily ridership. TANROADS also pointed to fragmented stakeholder coordination as a contributing factor. Infrastructure development is often conducted in silos, with insufficient collaboration between national road agencies, Town planners, and public transport regulators like LATRA. This institutional disconnect impedes the implementation of robust and intermodal solutions capable of mitigating congestion and passenger overcrowding at key transit points.

Urban Design Inadequacies (Urban Planning Perspective)

The city's Town Planner echoed and expanded upon these infrastructural critiques. Responses given by the Town Planning office revealed that specifications in terms of the position and sizes of bus stops are not mandated by the Town Planning office. The Planning office is only responsible for the allocation of Land for transportation purposes; the specifics of the transport infrastructure and technologies lie to TANROADS.

The Town planning office acknowledged that lack of spatial foresight in locating and sizing these stops intensify pedestrian clustering and restricts the smooth boarding of buses, especially in high-density commercial or market zones.

These views suggest that the existing bus stops are frequently the by-product of road engineering decisions or informal practices (as for the case of informal bus stops). This disjointed planning process results in mismatches between transit infrastructure and actual user demand, creating bottlenecks at locations that lack the physical or operational capacity to manage heavy foot traffic.

Both TANROADS and Town planners underscored that future-oriented, transit-supportive design principles such as transit-oriented development (TOD), pedestrian priority zoning, and integrated street furniture are still embryonic in Dar es Salaam's urban development framework. This delay hinders the city's ability to build a resilient and scalable public transport system responsive to current passenger overcrowding trends.

5.3 Discussion of Findings

5.3.1 Passenger Overcrowding Through the Theoretical Lens

The findings from this chapter strongly reinforce the conceptual framework of this study, which views passenger overcrowding at bus stops because of interlinked infrastructural, behavioral, operational, and technological variables. This aligns with Systems Theory, which posits that the performance of a transport system is dependent on the harmonious functioning of its interconnected subsystems, namely infrastructure, operations, user behavior, and governance. In this regard, the widespread overcrowding identified at major commuter bus stops in Dar es Salaam is not merely a function of increased demand but a manifestation of system-wide inefficiencies.

The Activity-Based Travel Demand Theory offers further insight into the temporal clustering of passenger flows, particularly during early morning and late afternoon hours. This theory emphasizes that travel demand is derived from individuals' daily activities and time constraints. The concentration of passengers during peak hours, as reported by both passengers and drivers, reflects the structure of urban life in Dar es Salaam, where economic activities and employment patterns are time-bound and spatially concentrated in the city center and commercial zones. This temporal rigidity contributes significantly to overcrowding trends observed in the study.

Additionally, the Technology Acceptance Model (TAM) is particularly useful in understanding the low adoption of intelligent mobility solutions among the surveyed population. Despite relatively widespread smartphone ownership, the actual usage of transport-related digital applications remains low. This suggests that the perceived usefulness and ease of use core determinants in TAM are not yet strong enough to influence behavior. Barriers such as digital illiteracy, lack of awareness, and insufficient technological integration contribute to this limited uptake, reducing the potential impact of intelligent mobility innovations on decongestion.

5.3.2 Interpretation of existing passenger overcrowding through the lens of reviewed works of literature

The observed causes of overcrowding resonate with a growing body of literature on urban transport challenges in sub-Saharan Africa. For instance, Litman (2021) underscores the role of inadequate infrastructure, such as the absence of shelters, seating, and clearly marked queuing zones, in exacerbating passenger congestion. Field observations at stops like Ilala Boma and Msimbazi confirm these shortcomings, with passengers exposed to harsh weather, traffic hazards, and disorderly boarding practices due to infrastructural neglect.

In alignment with Gakenheimer (1999) and Salon & Gulyani (2010), this study reveals that outdated urban transport plans and weak institutional coordination have left Dar es Salaam ill-prepared to manage its current mobility demands. As noted by TANROADS and the Ilala Municipality’s Town Planning Office, many bus stops still operate under spatial standards set decades ago, failing to reflect the city's population growth and evolving transport needs. The lack of coordination between agencies, such as road authorities, planners, and public transport regulators, further complicates efforts to modernize and expand the bus stop infrastructure.

The findings also mirror global research on Intelligent Transport Systems (ITS). Scholars such as Hossain and Muromachi (2012) emphasize that real-time passenger information (RTPI) systems, GPS-based fleet monitoring, and predictive scheduling tools can significantly reduce wait times and manage boarding flows. In the current study, both drivers and institutional stakeholders identified the absence of RTPI and unpredictable bus schedules as critical factors contributing to overcrowding. These gaps highlight missed opportunities for leveraging low-cost digital technologies to regulate and inform passenger behavior.

5.3.3 Infrastructure and Institutional Challenges

A recurring theme throughout the data is the inadequacy of infrastructure at commuter bus stops, especially innovative and/or technological supportive infrastructures. Passengers, drivers, and planners alike identified issues such as the lack of seating, insufficient shelter, absence of dedicated pick-up zones, and inadequate spatial capacity to handle peak-hour demand. These shortcomings directly contribute to physical clustering, prolonged dwell times, and unsafe boarding practices. For instance, field observations at Buguruni Sokoni and Tabata Bima revealed disorderly passenger flows and vehicle stoppages that extended into traffic lanes, creating hazardous conditions for both commuters and vehicles.

From an institutional standpoint, responses from TANROADS and the Town Planning Office highlight a fragmented policy and planning environment. While the Planning Office allocates land for transport use, it does not set technical specifications for bus stops. Meanwhile, TANROADS focuses on roadway efficiency rather than commuter experience, often prioritizing vehicle movement over pedestrian infrastructure. This siloed approach prevents the creation of integrated, user-friendly transit hubs. It also delays the implementation of forward-thinking design strategies such as Transit-Oriented Development (TOD) and multimodal connectivity, both of which are considered global best practices for sustainable urban mobility.

5.3.4 Operational and Behavioral Dynamics

Operational inefficiencies emerged as another major driver of overcrowding. From the drivers' perspective, limited fleet size, poor route coordination, and irregular bus schedules contribute significantly to passenger clustering. Drivers also described how the lack of centralized scheduling or real-time communication between buses often results in arrival clustering multiple buses reaching a stop at the same time, leading to bottlenecks and delays.

On the behavioral side, poor queuing discipline and lack of awareness around boarding protocols were frequently cited by both passengers and drivers. These findings are supported by prior studies (e.g., Cervero, 2000), which emphasize that passenger behavior shaped by culture, habits, and experience can influence the effectiveness of operational strategies. Without clearly marked queuing zones or enforcement of orderly boarding, spontaneous crowding becomes the norm, especially during rush hours.

5.3.5 The Role of Intelligent Mobility Solutions

Crucially, the findings show that 25% of the causes of overcrowding, as identified by drivers, are directly addressable through intelligent mobility interventions. The absence of real-time passenger information (11%) and irregular scheduling (14%) could be mitigated through technologies such as GPS-based tracking, digital signage, mobile apps, and smart ticketing systems. These tools can potentially help passengers plan trips more efficiently, reduce unnecessary wait times, and distribute boarding more evenly across the network.

However, as indicated by the Technology Acceptance Model, the success of such technologies depends on user readiness, intuitive system design, and institutional support. Introducing smart systems without adequate public education and operational integration may lead to low uptake and limited impact. Therefore, implementation strategies must include user sensitization campaigns and capacity-building efforts for operators and regulators.

5.3.6 Implications for Urban Transport Planning

The findings from this chapter emphasize that passenger overcrowding at commuter bus stops in Dar es Salaam is a complex issue rooted in both physical and systemic inadequacies. Addressing this issue requires a multidimensional response, that would carter across the 100% that makes up for causes of overcrowding. And since various efforts, as identified by Transportation authorities such as LATRA and TANROADS, to address the infrastructure-related challenges are already in place, this study offers the potential of lifting up 25% of what causes passenger overcrowding.

These findings therefore, support the study's argument that intelligent mobility, when appropriately contextualized, accepted by users, and supported by institutional coordination, can serve as a powerful tool in alleviating overcrowding and enhancing the efficiency of urban public transport systems in Tanzania and similar contexts

6. THE ROLE OF INTELLIGENT MOBILITY SOLUTIONS AND INSTITUTIONAL FRAMEWORKS

6.1 Introduction

The second objective of this study is to assess the role of intelligent mobility solutions and institutional frameworks in addressing passenger overcrowding at commuter bus stops. Intelligent mobility solutions (IMS), including Real-Time Passenger Information (RTPI) systems, GPS-based Vehicle tracking systems, mobile ticketing, and, among others, digital bus scheduling, represent emerging tools aimed at optimizing public transport operations, improving passenger flow, and enhancing user experience. This section presents the extent of awareness, adoption, and institutional integration of Intelligent solutions like these in Dar es Salaam, drawing from surveys with passengers, drivers, as well as key informant interviews with regulatory and infrastructure stakeholders.

6.2 Familiarity, Awareness, and Current Usage of Intelligent Mobility Solutions

6.2.1 Passenger Familiarity with Intelligent Mobility Solutions:

Passengers' survey results reveal a mixed but promising level of awareness among passengers regarding intelligent mobility/transport solutions. In response to Question 7 of the Passenger Survey, a considerable proportion of respondents (53%) indicated awareness of innovative technologies such as RTPI systems, though actual usage/interaction with such technologies remains low. A larger portion of Passengers (68%) reported having only heard about these solutions, the likes of Electronic and/mobile ticketing system and bus tracking applications, and only a small fraction (32%) have actively interacted with these tools. These results may be well attributed by digital literacy limitations, unreliable internet access, and, among others lack of familiarity with available platforms.

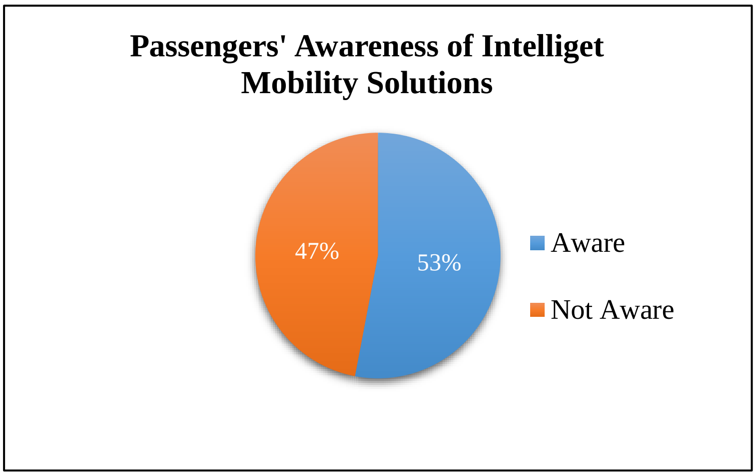


FIGURE 11 Passengers' Awareness of Intelligent Mobility Solutions

When it comes to access to information about bus arrival and departure at bus stops, 96% of passengers are still relying on informal and analog sources such as word of mouth (44%) and direct observation at the bus stops (52%). However, despite the discomfort and frustration these mechanisms offer to commuters, A substantial portion of respondents (64%) expressed interest in learning about and interacting with intelligent solutions, such as the use of vehicle tracking applications for bus tracking, if they were available, accessible, and user-friendly. However, challenges such as limited smartphone penetration, low awareness of app-based tools, and concerns about mobile data costs remain significant barriers to wider adoption, such challenges results to reluctance of a smaller portion of passengers (36%) who according to the survey conducted, are not ready to adopt and interact with innovative and intelligent solutions.

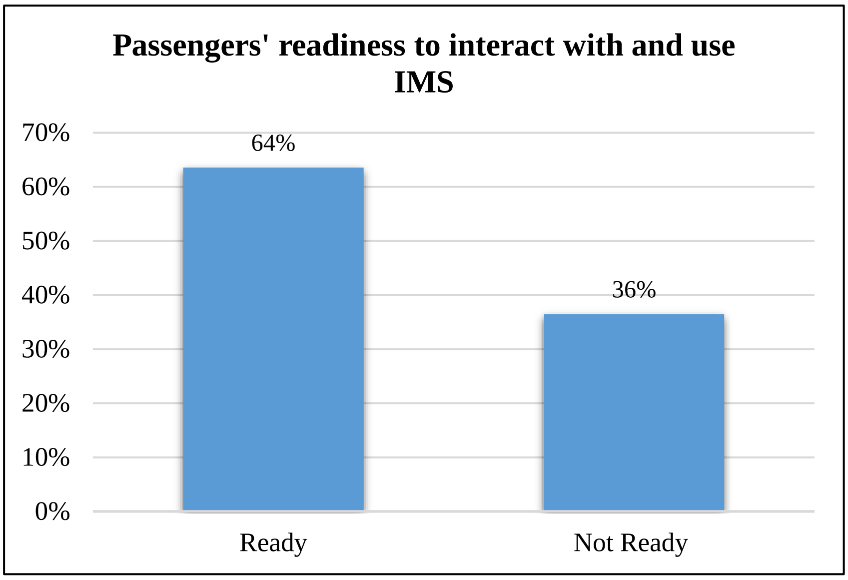


FIGURE 12 Passengers Willingness to Interact with IMS

Source: Author, 2025

6.2.2 Drivers' Familiarity with Intelligent Mobility Solutions (IMS)

A similar trend of limited exposure and usage of IMS was observed among commuter bus drivers. A survey conducted amongst these drivers shows that 93% of the drivers are aware of Intelligent Mobility solutions such as RTPI, VTD, etc. While most drivers are aware of these innovative technologies, very few (22%) have actually interacted with some of them in a professional or structured manner. Some drivers indicated improvised use of personal GPS apps (e.g., Google Maps or WhatsApp-based location sharing), mostly for navigation rather than operational scheduling.

The fact that Majority of the bus drivers are aware of a thing or two about Intelligent Mobility Solutions gives a promising future where adopting to these solutions would face minimal opposition from bus operators compared to what the situation would look like if they had not known what IMS entails. On the other hand, The fact that fewer drivers have actually interacted with such technologies indicates a gap in the scalable establishment and implementation of such solutions.

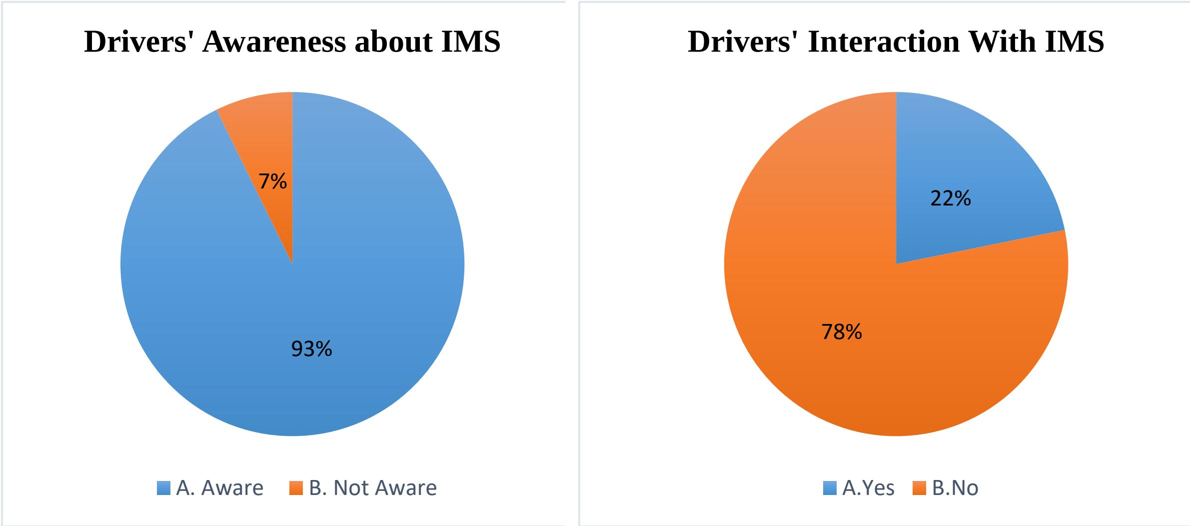


FIGURE 13 Drivers' Awareness Vs Actual Interaction with IMS

Source: Author, 2025

Notably, when asked about reasons for less usage of these solutions the majority cited lack of training, insufficient digital infrastructure, and absence of policy mandates as the primary reasons for non-use. Nevertheless, the overwhelming majority (97%) expressed a willingness to adopt such tools if provided with the necessary equipment, training, and institutional support signaling a readiness for innovation if systemic conditions are met.

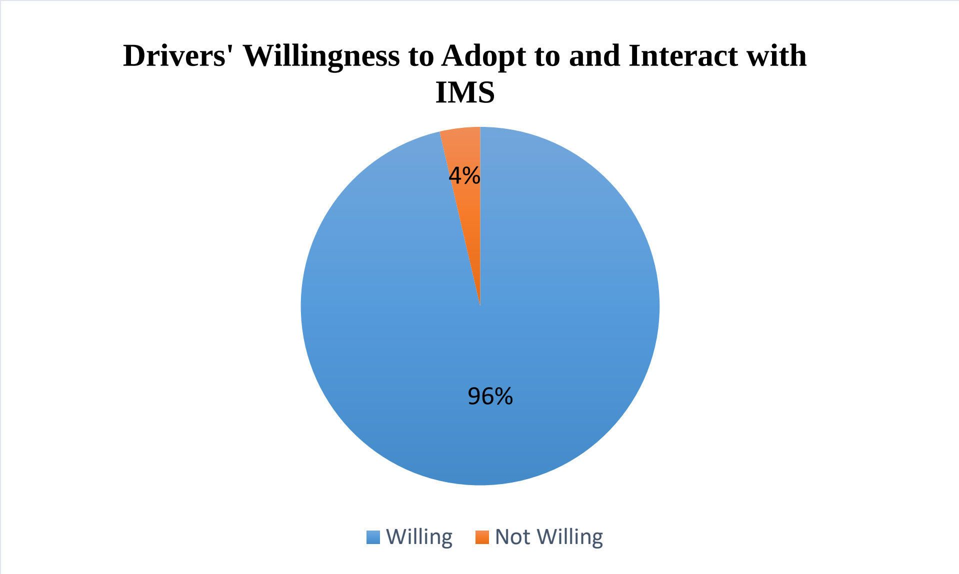


FIGURE 14 Drivers' Willingness to Interact with IMS

Source: Author, 2025

6.3 Institutional Integration of IMS: LATRA's Efforts

From an institutional standpoint, interviews with LATRA officials provided important insights into the current state of technology adoption within the public transport regulatory framework. LATRA acknowledged the exploratory use of some of the Intelligent Transport Technologies such as RTPI systems and automated fare collection in select pilot programs, particularly within the DART system. These initiatives involved installing digital displays at terminals and testing electronic ticketing systems. However, LATRA emphasized that these interventions remain fragmented, small-scale, and limited primarily to the BRT corridor, with minimal spillover into the broader daladala network that serves the majority of daily commuters.

Preliminary outcomes from the DART-based pilot revealed mixed results. On the positive side, the introduction of digital displays (embedded in BRT buses) helped improve passenger information accuracy and trip planning, particularly during peak hours. Likewise, the deployment of electronic ticketing systems demonstrated potential for reducing boarding times and improving fare transparency and revenue tracking. However, challenges such as technical maintenance, system downtime, and low public awareness or adaptation limited full-scale success. LATRA officials noted that interconnection issues, particularly with daladala operators, hindered expansion beyond the DART corridor. Additionally, limited funding and insufficient integration between transport and ICT infrastructure were cited as critical barriers to sustained implementation and scaling.

LATRA officials also noted the absence of a centralized digital infrastructure or nationwide platform for intelligent mobility coordination. While some systems have been piloted, no comprehensive regulatory framework currently compels or standardizes the adoption of such technologies among private operators (such as daladala owners). This is largely due to a combination of factors, including the highly fragmented nature of the commuter transport sector, where most daladala services are managed by loosely organized cooperatives or individual owners with minimal oversight by regulator (LATRA). In addition, there is currently no binding legislation or policy that mandates the integration of smart technologies, leaving adoption largely voluntary. Cost sensitivity is another significant barrier, as many private operators function on thin profit margins and perceive intelligent transport systems as financially burdensome without immediate return. Furthermore, weak enforcement mechanisms and limited digital infrastructure in many urban and peri-urban areas make it difficult for LATRA to monitor or enforce compliance effectively.

This regulatory gap contributes to the sporadic and informal use of digital tools, particularly among daladala (bus) drivers and operators, who often prioritize cost-saving over innovation in the absence of enforcement or incentives.

6.3.1 Effectiveness and Gaps in IMS Adoption and Usage

Despite their limited scale, pilot projects involving some of the Intelligent Mobility Systems have shown encouraging results. According to the LATRA and TANROADS projects, which implemented RTPI at select BRT stations and the Magufuli Bus Terminal, led to reduced waiting times, improved queue behavior, and higher passenger satisfaction. Real-time displays enabled commuters to stagger their arrival times and board more efficiently, thereby easing congestion at peak periods. Similarly, mobile ticketing trials reduced dwell times at busy terminals by speeding up the boarding process.

These early interventions demonstrate the transformative potential of IMS when strategically deployed. However, institutional officials were quick to acknowledge that the impact was localized and not yet scalable due to infrastructural, financial, and governance limitations.

The two Institutions acknowledged that the pilot projects, while proven successful, are only a reflection of what can possibly be implemented in the BRT and that the adoptability of such technologies in the commuter bus networks requires a massive reinvestment in supportive infrastructures and public awareness campaigns to tailor behavioral change among commuters.

6.3.2 Institutional Barriers and Integration Challenges;

Several institutional and technical barriers were identified as major impediments to the broader integration of intelligent mobility systems. First, there exists a fragmented governance structure, where responsibilities for public transport regulation, infrastructure provision, and urban planning are dispersed across multiple entities, LATRA, TANROADS, DART, and municipal authorities, without a unified digital strategy or communication framework.

Second, officials from both LATRA and TANROADS emphasized the lack of financial resources and technical expertise required to implement and maintain intelligent systems. For example, the installation of GPS trackers, digital display units, and fare automation systems requires upfront investment and recurring maintenance resources that are often unavailable or deprioritized in favor of basic operational needs.

Third, there are technical constraints embedded in the current bus stop infrastructure. Most daladala stops are not equipped with power sources, network connectivity, or secure mounting structures to support smart displays or sensors. TANROADS noted that the physical redesign of commuter bus stops is a prerequisite for integrating real-time technologies, yet such upgrades have not been mainstreamed into road planning processes.

Fourth, passenger diversity and digital inequality complicate implementation. LATRA acknowledged challenges in deploying digital tools to a commuter base with varied literacy levels, low smartphone access, and resistance to behavioral change. This concern is especially salient in informal transport systems dominated by vulnerable populations such as low-income workers, and students.

6.4 Discussion of Findings

The findings of this chapter align closely with the study's conceptual framework, particularly the Systems Theory, which emphasizes that resolving transport challenges like overcrowding requires integration across infrastructure, technology, behavior, and institutional systems. The limited adoption of Intelligent Mobility Solutions (IMS) in Dar es Salaam, especially outside the BRT corridor, reveals systemic fragmentation, where the absence of a unified digital strategy and institutional coordination weakens the overall performance of the urban transport network.

The Technology Acceptance Model (TAM) helps interpret passenger and driver behavior regarding IMS. While awareness of IMS is growing (53% of passengers and 93% of drivers reported some familiarity), actual usage remains low due to barriers such as limited training, digital literacy, and infrastructure. TAM suggests that adoption hinges on perceived usefulness and ease of use, both of which are currently undermined by high data costs, lack of user-friendly platforms, and minimal public education efforts.

Meanwhile, pilot initiatives implemented by LATRA and TANROADS validate the potential effectiveness of IMS, aligning with literature on Real-Time Passenger Information (RTPI) and digital ticketing systems. As observed by Hossain and Muromachi (2012), such systems can reduce waiting times, improve queue behavior, and enhance the passenger experience, outcomes confirmed in BRT and Magufuli Bus Terminal pilots.

6.4.1 Institutional Readiness and Gaps

Despite the early success of IMS pilots, scalability remains limited due to institutional and structural challenges. The study's findings resonate with Banister (2008), who emphasized that fragmented governance and siloed operations are significant barriers to sustainable urban mobility. LATRA's and TANROADS' acknowledgment of overlapping mandates and the absence of a centralized implementation framework illustrates how institutional disconnect delays digital transit transformation.

Additionally, the lack of budgetary allocation, technical capacity, and physical infrastructure such as powered and networked bus stops, limits the integration of smart systems across the broader daladala network. These issues are compounded by social factors, including digital inequality and resistance to change among both commuters and operators.

6.4.2 Implications for Intelligent Mobility Integration

Encouragingly, both passengers and drivers show strong interest in adopting IMS, provided that adequate training, infrastructure, and regulatory support are in place. This aligns with the principle of adaptive institutional frameworks, where successful technology implementation depends not just on tools, but on human and organizational readiness.

For intelligent mobility to contribute meaningfully to reducing overcrowding, it must be scaled beyond pilot zones and embedded within broader transport and urban planning policies. This includes mainstreaming IMS requirements into bus stop design, harmonizing digital strategies across agencies, and investing in capacity building for both users and implementers.

7. PASSENGER BEHAVIOR AND ADAPTABILITY TO INTELLIGENT TRANSPORT SOLUTIONS

7.1 Introduction

Understanding how passengers respond to challenges of overcrowding and whether they are open to adopting intelligent mobility solutions is central to recommending and/or designing effective, user-responsive interventions. The third research objective sought to explore commuter behavior patterns and adaptability in relation to both existing transit inefficiencies and proposed intelligent-based interventions. This section presents findings from both passenger and driver surveys, and later on complemented by institutional insights.

7.2 Overcrowding adaptation Strategies

The field results found that passengers in Dar es Salaam exhibit a range of adaptive behaviors in response to persistent overcrowding at commuter bus stops. These behaviors were captured through the Passenger Survey as well as field observations made throughout the survey

When asked about how they are adapting to a crowded bus stop, a large portion of respondents (56%) reported that their main solution is to wait patiently until they get a chance to board the bus, even if that happens under uncomfortable conditions. This response is indicative of both inadequacy in transport alternatives and a high dependency on daladala services. However, other strategies were also evident. 22% of passengers indicated they switch to alternative transport modes, such as bodabodas (motorcycle taxis), bajajis, or informal carpooling arrangements when congestion is extreme or prolonged, Another 15% reported that they sometimes walk to nearby or less congested bus stops, particularly when the anticipated wait time exceeds 15–20 minutes, A smaller yet significant proportion (7%) indicated that they intentionally shift their travel time, i.e either departing earlier or delaying their trip to avoid peak-hour overcrowding.

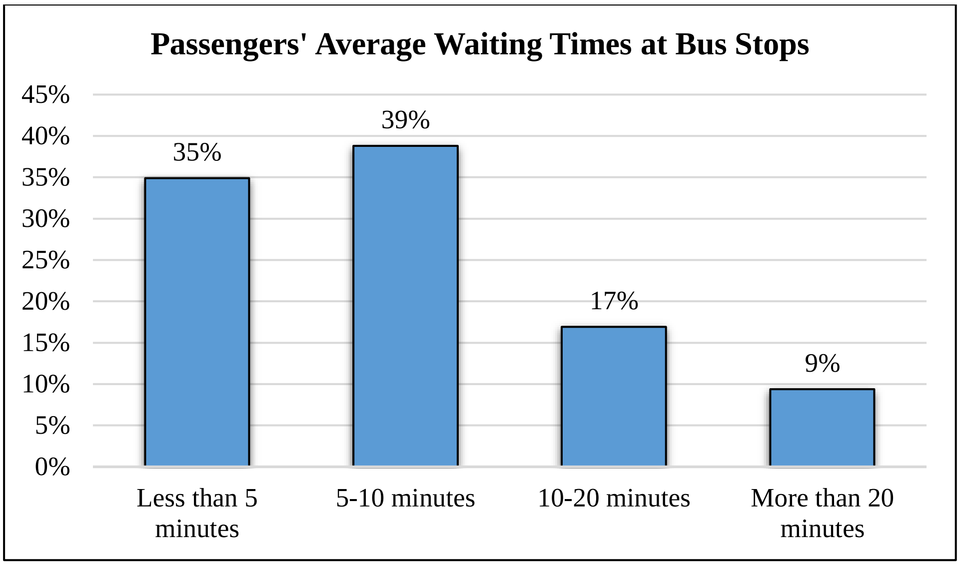
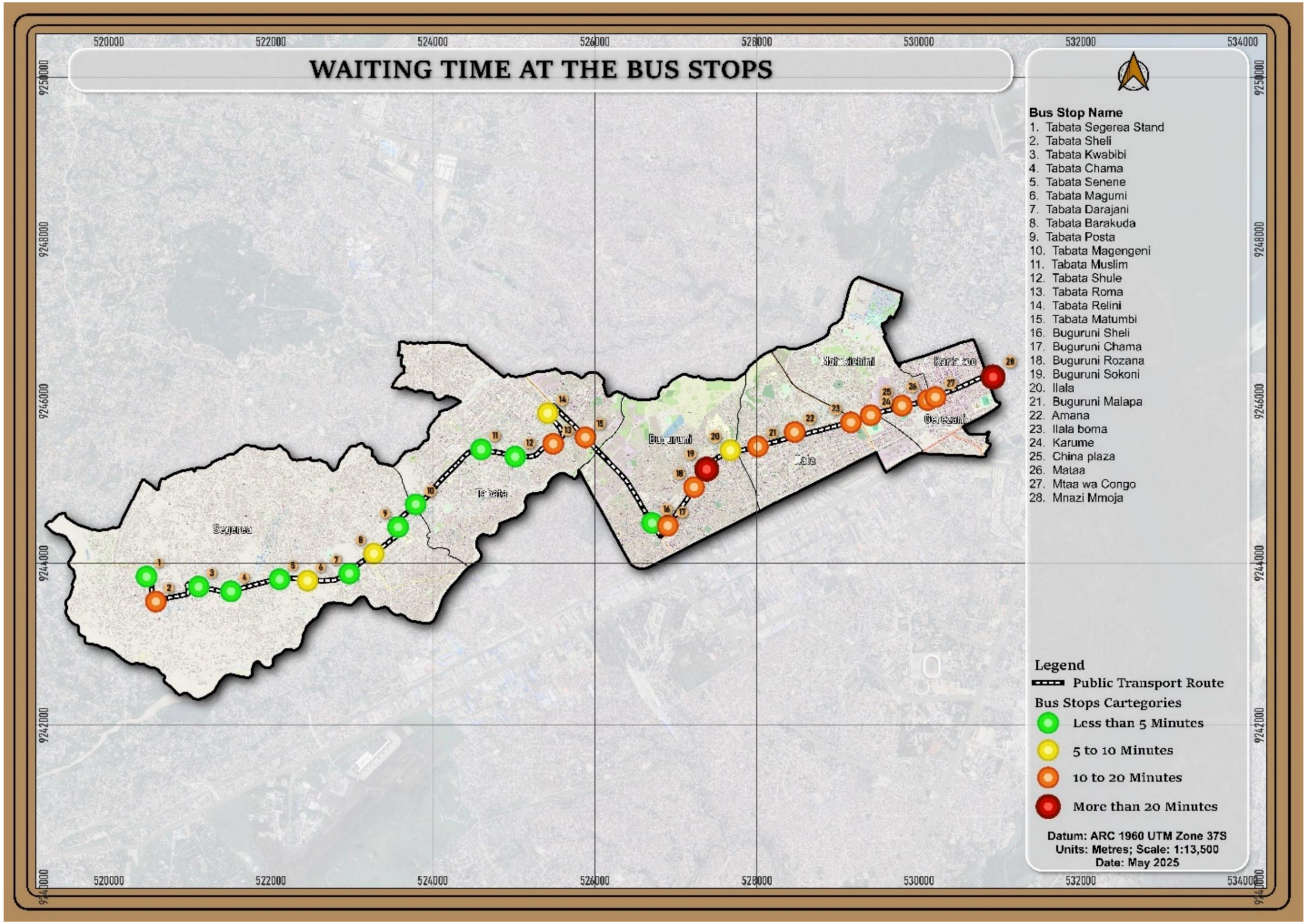


FIGURE 15 Passengers' Average Waiting Times across all bus stops

Source: Author, 2025

On the other hand, field observations across 28 bus stops of the selected area of study revealed distinct spatial patterns of passenger waiting times, which further illustrate behavioral adaptations to overcrowding. As shown in Map 4, the map categorizes bus stops based on average waiting durations recorded during peak hours. Bus stops marked in red such as Buguruni Sokoni and Mnazimmoja bus stand experienced waiting times exceeding 15 minutes indicating severe congestion/overcrowding and limited bus frequency. Bus stops marked in Orange such as Buguruni Sheli and Ilala Boma experience 5-10 minutes of waiting time, On the other hand, areas in green, especially in the western part of the corridor (e.g., Tabata Segerea and Tabata Bima), exhibited relatively lower waiting times, often under 5 minutes.

These spatial differences help explain why some passengers reported walking to less congested stops or adjusting travel times, practical responses shaped by the uneven distribution of service efficiency along the corridor. The geographic visualization, thus, reinforces the survey findings and underlines the necessity for targeted interventions in high-delay zones where passenger frustration and coping behaviors are most pronounced.



MAP 4 Average Waiting Times at Bus Stops

Source: Author, 2025

These findings suggest that while many passengers remain constrained by economic or locational limitations, there is a level of behavioral elasticity among a subset of commuters who are able to adjust their travel choices. However, these adaptations often come at the cost of additional time, safety, or financial burden.

From the driver and institutional perspective, additional behavioral dynamics were noted. Drivers reported that during overcrowded conditions, passengers often engage in aggressive boarding tactics, including pushing, verbal confrontation, or bypassing queues. These behaviors increase loading times and pose risks to safety and service order. LATRA and urban planners noted that such behaviors are exacerbated by the lack of formal queuing systems and real-time information, which leads to frustration, uncertainty, and ultimately, reactive conduct.

There was also a reported resistance to change in commuter habits, especially among older or lower-income passengers. LATRA highlighted that attempts to introduce queue control, digital ticketing, or scheduled dispatch systems often met skepticism or slow uptake, suggesting that any intervention must be accompanied by robust public education and user sensitization campaigns.

7.3 Commuters' willingness to interact with and use Intelligent/innovative Transport Technologies for best Behavioral Practices

Passenger and driver attitudes toward intelligent mobility solutions, particularly those involving information technology, reveal critical insights into the feasibility of digital interventions for passenger decongestion at bus stops.

7.3.1 Passenger Attitudes:

It was observed from passenger surveys that a majority of passengers expressed a positive disposition toward mobile applications that could provide real-time bus tracking, with 65% indicating a willingness to use such tools if made available and accessible. However, barriers to adoption remain prominent. About 29% cited lack of smartphones, limited digital literacy, or concerns over mobile data costs as factors that could prevent regular use of transport apps, and that they are not willing to use such tools. In terms of digital fare payments, over half of respondents had never used mobile ticketing, and among them, concerns about security, unfamiliarity, and lack of infrastructure (e.g., card readers or verification systems) were dominant, this indicates a strong demand for ICT-enhanced services, but actual usage is significantly constrained by socioeconomic and infrastructural barriers.

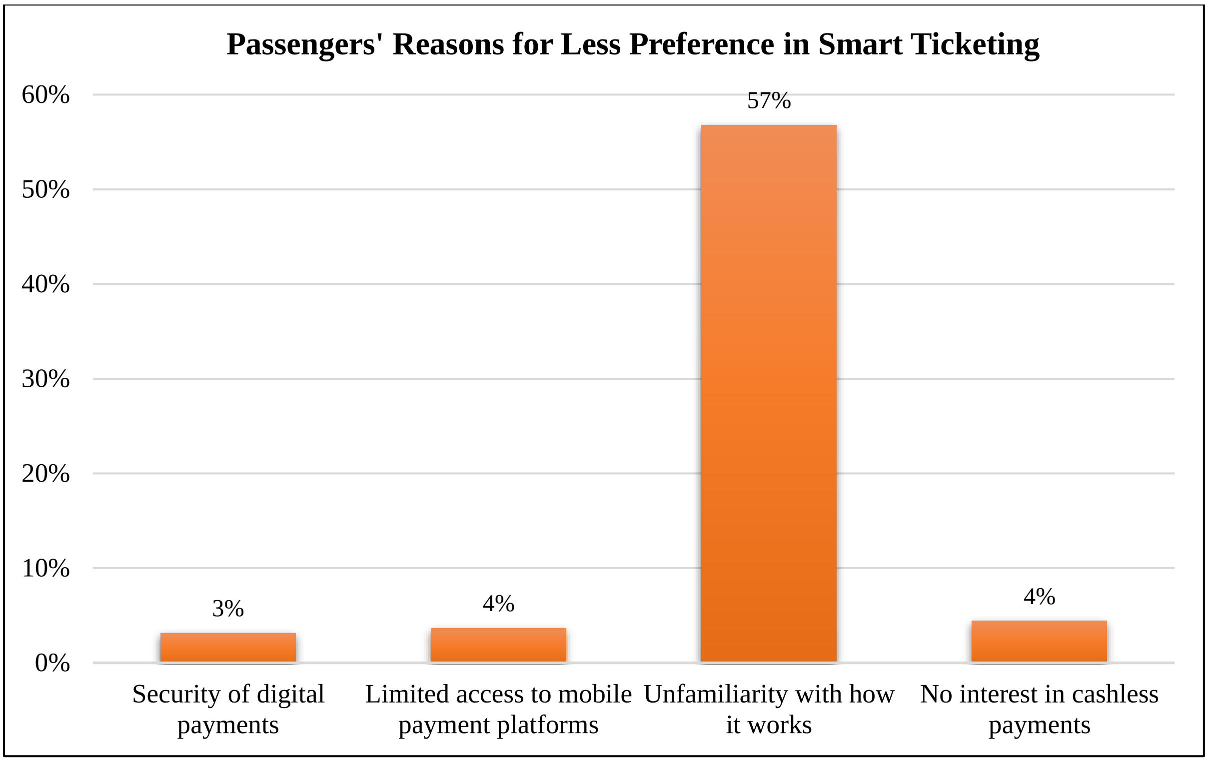


FIGURE 16 Passengers' Reasons for Less Preference in Smart Ticketing

Source: Author, 2025

7.3.2 Driver Attitudes:

Driver responses revealed similar trends. The majority of drivers (78%) had not yet interacted with formal intelligent mobility platforms in their operational context, but over 70% expressed willingness to adopt technologies such as mobile dispatch tools, GPS tracking, or digital ticketing systems. Their enthusiasm was often conditional, with key forewarnings being; The need for proper training and onboarding, drivers feared that misuse or misinterpretation of digital tools could result in penalties or service errors, Concerns about cost, especially in scenarios where drivers or owners would need to purchase or maintain hardware (e.g., smartphones, GPS units), Skepticism about enforcement, as some drivers felt that introducing technology would expose them to new regulatory scrutiny without delivering immediate operational benefits.

Despite these concerns, both passengers and drivers demonstrated a willingness to modernize provided that digital solutions are affordable, inclusive, and practically useful.

7.4 Discussion of Findings

The results presented in this chapter reveal important insights into how commuters in Dar es Salaam respond to overcrowding and their willingness to engage with intelligent mobility technologies. These findings, when interpreted in light of the literature and conceptual frameworks reviewed earlier, highlight both systemic constraints and latent opportunities for more responsive transport planning in developing urban contexts.

7.4.1 Commuter Adaptation in the Face of Overcrowding

The finding that a majority of commuters (56%) resort to waiting passively at overcrowded bus stops underscores the absence of viable modal alternatives and reaffirms the entrenched dependency on daladala services. This passive adaptation mirrors patterns observed in other sub-Saharan African cities, where informal transport dominates in the absence of integrated systems (Behrens et al., 2016). As the literature suggests, when formal planning does not adequately address mobility needs, passengers develop their own coping mechanisms (Lucas, 2011). In this case, behaviors such as walking to less congested stops or altering departure times (as reported by 15% and 7% of respondents, respectively) represent practical but suboptimal adaptations that shift the burden of inefficiency onto the user.

Furthermore, the field-mapped spatial disparities in waiting times echo findings by Kombe and Lupala (2019), who emphasized the uneven geography of service delivery in Dar es Salaam's public transport system. That passengers walk to more efficient stops reflects an implicit rationalization of the system's unreliability, akin to what Cervero (2013) described as "self-planned mobility" a condition where users must develop spatial and temporal strategies to navigate fragmented transport networks. These adaptations, while resourceful, often involve trade-offs in time, safety, and comfort, especially for marginalized populations.

Aggressive behaviors reported during boarding, such as queue jumping or confrontations, further highlight the breakdown of normative behavior under system stress. This observation aligns with Barter (2002), who found that the absence of infrastructure to regulate passenger movement (e.g., queuing barriers or scheduled boarding) leads to reactive and often chaotic conduct. The findings also support the argument advanced by Shaheen and Cohen (2013), who advocate for demand management interventions that combine physical design (e.g., boarding lanes) with behavioral nudges to restore order in transit spaces.

7.4.2 Readiness to Adopt Intelligent Mobility Solutions

While the field data reveals strong latent demand for intelligent mobility tools, particularly mobile applications for real-time passenger information (RTPI), the barriers to adoption are equally notable. The 65% of respondents who expressed interest in such tools reflect the growing awareness of digital transport innovations, confirming the relevance of concepts reviewed in Benevolo et al. (2016), who found that urban residents, particularly in congested cities, are eager for solutions that improve predictability and reduce waiting uncertainty.

However, the persistence of barriers such as limited smartphone ownership, digital literacy, and data costs, cited by 29% of passengers, reinforces the digital divide highlighted by Mtega and Malekani (2009). These findings align with literature from the Global South, indicating that ICT-enabled transport services must be designed for inclusivity, considering the infrastructural and economic disparities that influence technology access (Zhao et al., 2018).

From a theoretical lens, the Technology Acceptance Model (TAM) helps explain the ambivalence observed in both passengers and drivers. While the perceived usefulness of intelligent mobility tools is high, the perceived ease of use remains constrained. For instance, the low uptake of mobile ticketing despite conceptual support reflects insufficient infrastructure and fears about digital security, which the TAM framework recognizes as critical to adoption behavior (Davis, 1989). Moreover, drivers' concerns regarding misuse, regulatory exposure, and upfront costs further echo this dynamic, suggesting that without proper onboarding, training, and institutional assurances, even well-intentioned innovations may fail to penetrate operational routines.

7.4.3 Institutional Resistance and Cultural Frictions

The study also uncovered deeper behavioral and cultural resistance to change, particularly among older or low-income commuters who are less familiar with digital tools. LATRA’s difficulty in implementing queuing systems and digital ticketing reflects institutional inertia and skepticism among users. These findings align with insights from Lucas (2011), who argued that transport reforms in low-income contexts must navigate entrenched habits, distrust in governance, and historical neglect of user needs. Change, therefore, requires not only technical solutions but deliberate public engagement and education campaigns.

Systems Theory is particularly instructive here. Passengers’ behaviors whether passive waiting, resistance to queuing, or informal trip planning can be interpreted not as irrational decisions but as rational responses to a fragmented, unreliable system. The theory posits that human actions are shaped by the broader organizational and infrastructural environment. In this case, the lack of timely service, limited fare integration, and poor information systems drive commuters to adopt coping strategies that minimize uncertainty in a complex system.

Furthermore, Systems Theory underscores the importance of viewing interventions not as isolated fixes, but as part of a holistic system redesign. Asking people to queue or use apps will remain ineffective unless embedded within supportive infrastructure (e.g., signs, barriers, and scheduling tools), governance mechanisms (e.g., monitoring and feedback), and social systems (e.g., public trust and awareness).

Ultimately, the findings affirm a central conclusion from the literature: that technological solutions alone are insufficient to solve complex urban transport challenges. As noted by Papa and Ferreira (2018), smart mobility must be people-centered, responsive to socio-economic realities, and grounded in institutional capacity. The study illustrates that both passengers and drivers are open to innovation but only within a context that acknowledges their constraints and includes them in the design and implementation process.

Therefore, future interventions must be integrated, inclusive, and iterative, incorporating user feedback, localized trials, and infrastructural support. Bridging the behavioral gap between current practices and smart mobility ideals will require more than innovation; it will require a co-evolution of infrastructure, governance, and commuter culture an insight strongly supported by both the literature and the conceptual models underpinning this study.

8. EFFECTIVENESS OF VARIOUS INTELLIGENT MOBILITY SOLUTIONS

8.1 Introduction

The fourth objective of this study was to evaluate the actual and perceived effectiveness of intelligent mobility solutions (IMS) in reducing passenger congestion at commuter bus stops. This analysis is critical for determining not only the utility of tools and interventions in theory, but also their real-world performance, adoption challenges, and contextual applicability within Dar es Salaam's unique transport environment. Drawing on field data and institutional reflections particularly from LATRA and TANROADS, this chapter unpacks the efficacy, limitations, and strategic potential of intelligent transport interventions.

8.2 Perceived and Real Benefits of Intelligent Mobility Solutions (IMS)

While intelligent mobility solutions are still at a bourgeoning stage in Tanzania's public transport sector, early experiences suggest that their deployment, even in limited contexts, can generate meaningful operational and behavioral shifts. LATRA officials, referencing previous pilot efforts on the DART BRT corridor, reported several benefits of implementing real-time passenger information (RTPI) systems, notably, Improved passenger flow through more predictable boarding behavior, Reduced waiting anxiety as passengers could anticipate arrival times and adjust accordingly and Enhanced crowd dispersion, particularly at terminals with digital displays, as commuters were less inclined to cluster in panic or haste.

Electronic ticketing systems piloted within limited BRT routes were also perceived as successful in reducing dwell time and speeding up boarding. These systems not only optimized bus stop interactions but also introduced transaction transparency, allowing operators and regulators to monitor usage patterns and revenue flows more accurately.

Passengers and drivers echoed these institutional assessments. Respondents generally agreed that RTPI systems and digital communication tools could significantly alleviate congestion by minimizing uncertainty, reducing unnecessary waiting, and encouraging staggered arrival at stops. Drivers emphasized that smart dispatch systems could help optimize route planning and prevent vehicle bunching at popular terminals.

In essence, both perceived and actual experiences with IMS show alignment: when introduced with sufficient infrastructure, training, and institutional support, digital systems enhance operational fluidity and reduce congestion.

8.3 Institutional Reflections: Challenges and Gaps

Despite the demonstrated benefits, interviews with LATRA and TANROADS officials revealed several institutional, infrastructural, and systemic barriers to wide-scale effectiveness. These gaps, which significantly hinder the scalability and equity of intelligent mobility integration, include;

8.3.1 Fragmentation and Weak Policy Frameworks:

One of the most prominent challenges cited by LATRA is the absence of a cohesive national policy or digital roadmap for intelligent mobility. Current efforts are often isolated, piloted in specific corridors (e.g., BRT Phase 1), and lack formal integration into the city-wide commuter transit system. This policy vacuum persists in part because intelligent mobility has not yet been fully mainstreamed into national transport planning or budgeting frameworks, and key actors in the sector still regard these technologies as experimental rather than essential. Daladala operators remain outside the digital fold, largely due to weak regulatory mandates and limited incentives for innovation. Most operate informally and prioritize short-term operational costs over long-term system upgrades, particularly in the absence of clear legal obligations or financial support mechanisms.

TANROADS emphasized the disconnect between infrastructure planning and smart system requirements. While road expansions and bus stop redesigns are underway, there is little consideration for digital upscaling, such as installing power sources, data points, or protected zones for smart devices. This is partly because road infrastructure projects are still conceived through a traditional civil engineering lens, with limited collaboration between transport planners, ICT specialists, and urban mobility innovators. As a result, this oversight creates a misalignment between hardware availability (smartphones, apps) and software functionality (RTPI platforms, fleet tracking), undermining the potential for seamless integration of smart mobility services into the physical transit environment.

8.3.2 Financial and Technical Constraints:

Both LATRA and TANROADS acknowledged significant resource limitations in scaling up intelligent mobility. RTPI systems require investment in GPS infrastructure, server maintenance, and public-facing devices like screens or SMS gateways. Without donor support or public-private partnerships, such systems remain unaffordable at the national scale. While there are clear opportunities for PPPs, particularly in areas like data management, system integration, and infrastructure financing, their implementation has been limited by regulatory ambiguity, weak institutional coordination, and lack of clear risk-sharing frameworks. In many cases, private firms are hesitant to invest without guarantees on returns, stable contracts, or long-term policy commitments from the government. As a result, PPPs in the intelligent mobility space remain underdeveloped despite their potential to accelerate innovation and funding.

Moreover, technical capacity within institutions remains limited. Interviewees admitted to gaps in data science skills, software integration, and system maintenance, which complicate efforts to develop or manage intelligent mobility platforms sustainably.

8.3.3 Socioeconomic Barriers and Equity Concerns;

Even where systems are operational, equitable access remains a challenge. LATRA officials raised concerns about digital exclusion, particularly for commuters without smartphones, the elderly, and low-literacy populations. Without multi-modal communication strategies (e.g., combining mobile apps with SMS alerts or digital signboards), intelligent mobility systems risk reinforcing existing inequalities in access to transport services.

Finally, resistance to change among both operators and users was highlighted as a critical cultural barrier. Many stakeholders perceive digital interventions as surveillance tools or bureaucratic burdens rather than enablers of efficiency, especially in informal transport settings. This highlights the importance of behavioral framing, stakeholder buy-in, and phased implementation models.

The findings suggest that intelligent mobility solutions have proven effectiveness in controlled environments, particularly within the formal BRT system. They reduce queue buildup and waiting time, enable more equitable and predictable access to transport, and support more efficient operational planning and passenger management.

However, their effectiveness is diminished in semi-regulated contexts such as that of daladala (commuter buses) or where system integration, user training, and infrastructural readiness are absent. The potential of IMS to alleviate overcrowding is not in question, but its translation into systemic solutions requires comprehensive policy alignment, technological capacity-building, and deliberate attention to inclusion and equity.

9. SYNTHESIS OF KEY FINDINGS AND IMPLICATIONS

9.1 Introduction

This chapter synthesizes the major findings derived from the previous chapters, specifically Chapters 5 through 8, in alignment with the study's overall objectives and conceptual framework. By consolidating the outcomes across different dimensions of analysis, this chapter provides a cohesive understanding of how intelligent mobility solutions can address passenger overcrowding at commuter bus stops in Dar es Salaam. Additionally, the chapter explores cross-cutting themes that emerged throughout the research and highlights practical and policy implications for sustainable urban mobility management in Tanzania.

9.2 Cross-Cutting Issues Across Research Question

This section presents an integrated synthesis of the findings across all four research objectives, focusing on critical cross-cutting issues that influence passenger overcrowding at commuter bus stops. These interlinked themes, infrastructure and operations, institutional readiness, passenger behavior and adaptability, and the conditional effectiveness of technological interventions, collectively shape the feasibility and impact of intelligent mobility solutions in Dar es Salaam. Understanding how these issues connect across objectives provides a pathway for addressing the study's overall aim: to explore how intelligent mobility solutions can mitigate overcrowding and improve public transport efficiency.

9.2.1 Infrastructure and Operational Inefficiencies

The first research objective sought to identify key factors contributing to overcrowding at bus stops. The findings revealed that infrastructure and scheduling inefficiencies are at the core of the problem. Most bus stops along the Mnazi Mmoja–Tabata Segerea corridor lack formalized design, adequate queuing space, and clear signage. These physical constraints, combined with erratic bus scheduling and inconsistent service frequency, especially in the daladala system, create serious bottlenecks during peak hours.

These infrastructure and operational limitations do more than inconvenience passengers; they directly contribute to unsafe conditions, increase perceived waiting times, and heighten tension at transit points. This aligns with Systems Theory, which frames transit inefficiencies as emerging from weakly coordinated subcomponents, in this case, bus stop layout, traffic conditions, and fleet dispatch.

This foundational problem sets the stage for the next set of issues, particularly how institutions are (or are not) equipped to respond to these deficits using intelligent systems.

9.2.2 Institutional Readiness and Digital Infrastructure Gaps

Building on the operational challenges uncovered in Objective 1, the second objective focused on assessing the role of intelligent mobility solutions and institutional frameworks. Here, it became clear that institutional readiness is critically lacking, especially outside the formal Bus Rapid Transit (BRT) system. LATRA and other regulatory agencies have yet to develop a cohesive, city-wide digital transit strategy that integrates real-time data, scheduling systems, or smart payment platforms for the daladala sector.

Fragmentation in governance, insufficient technical capacity, and outdated policies are key obstacles. Even where intelligent mobility tools have been piloted, such as at select DART terminals, there has been little scaling or policy-driven replication. The findings also revealed that digital infrastructure remains concentrated in limited urban zones, and there are no mechanisms in place to support real-time monitoring or automated fare collection across informal routes.

This institutional gap inhibits any meaningful application of intelligent mobility and reinforces the operational inefficiencies highlighted in Objective 1. Without leadership, investment, and reform at the institutional level, infrastructure improvements alone cannot address the complexities of overcrowding.

9.2.3 Passenger Behavior and Adaptability

As Objective 3 explored, the success of both infrastructural improvements and institutional initiatives ultimately depends on the behavior and adaptability of passengers and operators. The study found a mixed picture: While younger, tech-literate commuters expressed interest in using mobile apps and digital fare systems, many other passengers lacked access to smartphones or understanding of how such systems work. Furthermore, entrenched behaviors, such as disorganized queuing, informal boarding, and reliance on verbal communication rather than scheduled information, limit the effectiveness of even the best-designed interventions.

Drivers and daladala operators also displayed resistance to adopting intelligent systems, largely due to fear of income loss, job restructuring, or unfamiliarity with digital platforms. These insights reflect the importance of behavioral integration within the broader smart mobility agenda. The Technology Acceptance Model (TAM) becomes particularly relevant here, as it emphasizes perceived ease of use and usefulness as key factors in technology adoption.

Passenger and operator behavior acts as a filter, mediating whether institutional policies and technological tools will translate into practical improvements at the bus stop level. This underscores the need for targeted awareness campaigns, public engagement, and behavioral nudging as part of any future decongestion strategy.

9.2.4 Conditional Effectiveness of Technological Interventions

The final objective examined the effectiveness of intelligent mobility solutions themselves. The study found high potential in tools such as Real-Time Passenger Information (RTPI), digital fare systems, and mobile trip planning apps. However, these tools are only effective when introduced within an enabling environment, something currently lacking across the daladala system. In cases where RTPI has been deployed within the BRT system, the benefits include reduced perceived wait times, better passenger distribution, and improved satisfaction. However, when these same tools are proposed for the informal sector, challenges quickly emerge due to infrastructure deficits, institutional fragmentation, and behavioral resistance.

This insight ties back to all previous objectives. Without sound infrastructure (Objective 1), institutional readiness (Objective 2), and behavioral alignment (Objective 3), technological solutions cannot thrive. Intelligent mobility is not a standalone fix but a complementary strategy that must be interwoven with policy reform, public education, and system-wide investment.

9.3 Bridging the Findings to the Overall Objective

Taken together, the findings from each objective reveal a chain of dependency, infrastructure limitations create congestion; weak institutions fail to address it systemically; behavioral factors shape how solutions are received; and smart technologies only succeed when all other components are aligned. This interdependence illustrates the core message of the study: Intelligent mobility solutions can significantly alleviate passenger overcrowding at bus stops, but only when implemented through an integrated, system-oriented approach.

This synthesis validates the conceptual framework of the study, which positioned infrastructure, operations, policy, technology, and commuter behavior as interrelated variables. It also reinforces the need for a multi-sectoral strategy that moves beyond isolated interventions to embrace systemic change. The next section presents a summary of these findings as aligned with each research objective.

9.4 Comparative Insights from Literature and Policy Context

The findings of this study strongly resonate with existing global and regional scholarly literature on intelligent mobility and public transport management. In particular, the use of Real-Time Passenger Information (RTPI) systems and digital fare collection has been widely acknowledged in cities such as Kigali, Singapore, and Seoul as effective means to reduce perceived waiting times, optimize boarding processes, and enhance overall passenger satisfaction. In these contexts, the integration of digital tools into formalized transit networks has yielded significant improvements in service efficiency and commuter experience. This study reinforces those conclusions by showing that passengers in Dar es Salaam, particularly younger and more tech-aware groups, respond positively to digital innovations, provided that the tools are accessible, user-friendly, and contextually appropriate.

However, the Dar es Salaam case introduces unique challenges that are less explored in the mainstream literature. Unlike cities with unified transit systems, Dar es Salaam operates under a dual system of formal BRT (managed under DART) and informal daladala services. This coexistence creates structural and operational contradictions that complicate the integration of intelligent mobility tools. While BRT terminals can support RTPI, ticketing automation, and centralized scheduling, the daladala sector lacks standardized operations, digital readiness, and regulatory enforcement. As a result, even promising smart mobility solutions face systemic barriers to scale-up in mixed-operating environments, a reality that distinguishes Dar es Salaam from more homogeneous transit models discussed in comparative studies.

From a policy perspective, the findings reveal a persistent gap between strategic vision and actual implementation. The National Transport Policy (2003) and the DART Master Plan (2008) both emphasize modernization of public transport through institutional reform, infrastructure improvement, and technological innovation. These policies acknowledge the role of ICT in achieving operational efficiency and user convenience. However, implementation has been skewed toward formal systems like BRT, while the daladala sector serving the majority of urban commuters, remains marginalized in both policy design and enforcement. No clear digital integration roadmap currently exists for informal routes, nor is there a comprehensive institutional mandate to drive system-wide intelligent mobility transformation.

Additionally, urban planning and municipal transport regulations do not sufficiently account for the spatial and operational needs of commuter bus stops, especially in informal areas. Many bus stops fall outside formal zoning or infrastructural investment plans, limiting their ability to absorb smart infrastructure or benefit from digital services. This regulatory oversight reinforces inequities in transport access and underscores the need for targeted, inclusive, and phased policy updates that cover all tiers of public transport, not just the most visible or well-funded systems.

Taken together, these insights point to a crucial policy recommendation: Tanzania's transport strategy must evolve from focusing on system-level modernization to embracing network-wide integration, particularly by embedding intelligent mobility solutions in both formal and informal operations. Without this, intelligent mobility will remain a fragmented innovation, accessible only to a subset of commuters, and unable to resolve the widespread problem of bus stop overcrowding.

9.5 Reflections on Theories and the Conceptual Framework

The application of Systems Theory provided a critical lens through which to understand the interconnectedness of the variables contributing to overcrowding at commuter bus stops. This theory posits that complex problems, like urban transport inefficiencies, arise not from isolated factors but from dysfunctional interactions among components. In this study, infrastructure limitations, scheduling failures, fragmented institutions, and behavioral patterns all interacted to produce the observed crowding effects. Systems Theory helped trace these interdependencies, revealing how the failure of one element (e.g., scheduling) could cascade into others (e.g., user dissatisfaction and resistance to boarding discipline), thereby deepening congestion.

The Technology Acceptance Model (TAM) also proved highly relevant in contextualizing the study’s findings. TAM emphasizes user perceptions, particularly regarding ease of use and perceived usefulness, as critical predictors of technology adoption. This was evident among passengers who expressed willingness to use RTPI systems or digital payment methods but were limited by unfamiliarity, lack of trust, or access barriers. Similarly, daladala operators' hesitation reflected concerns over control and usability. TAM thus provided a useful framework for understanding not only the acceptance of current digital tools but also the preconditions for their successful implementation across different commuter groups.

The Smart Mobility and Sustainable Transport Theory offered a guiding vision for aligning technology with sustainable urban development. It underscores the role of ICT in enhancing service accessibility, environmental efficiency, and equity in transport systems. However, this study revealed that for such benefits to be realized in Dar es Salaam, smart solutions must be tailored to local socioeconomic realities, including informal transit structures, limited digital literacy, and regulatory asymmetries. The theory’s aspirational elements must be grounded in incremental and inclusive innovation strategies to be applicable in developing city contexts.

Finally, the conceptual framework adopted in this study successfully linked the various dimensions of the problem into a coherent analytical model. It framed infrastructure, operations, institutional context, and user behavior as independent and moderating variables influencing the core outcome, passenger overcrowding. This framework allowed for a nuanced exploration of how intelligent mobility tools interact with both systemic structures and human elements, thereby offering a comprehensive lens for diagnosing transport challenges and evaluating solutions. It holds potential for replication in other urban settings where formal and informal systems coexist and where intelligent mobility is being considered as a policy solution.

10. RECOMMENDATIONS AND CONCLUSION

10.1 Recommendations

The study has demonstrated that passenger overcrowding at commuter bus stops in Dar es Salaam stems from a constellation of infrastructural, institutional, behavioral, and operational challenges. To address these complex issues effectively, this section proposes a set of targeted recommendations that are not only evidence-based but also tailored to the local context. These recommendations are intended to guide city authorities, transport regulators, and planning institutions in their efforts to implement sustainable and intelligent mobility solutions that are inclusive, scalable, and context-sensitive.

10.1.1 Infrastructure and Operational Improvements

a) Redesign and upgrade commuter bus stops to include adequate queuing space, weather protection, lighting, and clearly marked boarding areas.

To reduce overcrowding and improve the commuter experience, it is imperative to redesign and upgrade commuter bus stops across Dar es Salaam. Existing stops often lack fundamental features such as designated queuing areas, shelter from the elements, and adequate lighting. Upgraded infrastructure should include wider platforms, covered waiting zones, proper signage, and boarding rails to facilitate orderly entry. These features would significantly enhance passenger flow, promote safety, and support equitable access, particularly for vulnerable groups such as the elderly, women, and persons with disabilities.

b) Implement structured dispatch and scheduling systems for commuter bus operations.

Along with physical upgrades, operational improvements are essential, particularly in the public bus (daladala) sector. The current informal dispatching system results in erratic and uneven bus arrivals, which contributes to peak-hour clustering and passenger anxiety. Establishing structured dispatching and scheduling mechanisms will help regulate service intervals, reduce vehicle bunching, and distribute passengers more evenly throughout the day. This will not only reduce crowding but also improve operational predictability.

c) Prioritize congestion-sensitive locations.

Initial implementation efforts should be concentrated in high-congestion zones such as Mnazi Mmoja, Buguruni, and Tabata Segerea, which were identified in the study as particularly affected by overcrowding. These areas should serve as pilot corridors for integrated infrastructure and operational interventions.

The effectiveness of the improvements can be monitored through passenger flow data and user feedback, which will then inform broader city-wide rollouts.

10.1.2 Institutional Strengthening and Policy Reform

a) Update regulatory frameworks to explicitly incorporate intelligent mobility solutions into national and local transport plans.

For intelligent mobility solutions to take root and deliver meaningful impact, there must be deliberate efforts to strengthen institutional frameworks and reform transport policy. Existing regulatory instruments do not fully account for digital transformation in the transport sector. Updating these frameworks is necessary to formally recognize and integrate intelligent systems such as RTPI, mobile ticketing, and GPS-based fleet monitoring into both national and municipal transport strategies. Legal backing for these technologies will enhance compliance, standardize usage, and protect the interests of both operators and commuters.

b) Strengthen LATRA's technical and enforcement capacity to oversee digital integration of daladala systems.

Equally important is the enhancement of LATRA's technical capacity and regulatory enforcement. The agency must be equipped with specialized personnel, digital tools, and operational autonomy to manage and monitor digital integration across both formal and informal transport systems. While the BRT system has benefited from some level of digital oversight, the daladala sector continues to operate largely outside regulatory visibility. Empowering LATRA to extend its digital governance to this sector will be critical for system-wide consistency and performance improvement.

c) Foster inter-agency collaboration among urban planners, ICT providers, and transport regulators to support unified smart mobility strategies.

Moreover, there is a pressing need for improved collaboration across key stakeholders. Urban planners, ICT solution providers, and transport regulators often work in silos, leading to fragmented initiatives and missed opportunities for synergy. A coordinated approach, perhaps through the establishment of a Smart Urban Mobility Task Force, can help align policy objectives, technical standards, and resource allocation. Such inter-agency collaboration will be essential in designing, deploying, and scaling intelligent mobility solutions that are both technically sound and socially inclusive.

10.1.3 Enhancing Passenger Awareness and Digital Inclusion

a) Conduct sustained public education campaigns on the benefits and use of intelligent mobility systems, targeting passengers, drivers, and conductors.

A key determinant of the success of intelligent mobility systems lies in the awareness, trust, and digital readiness of their end users primarily passengers, drivers, and conductors. The study revealed that while many commuters express interest in adopting digital tools such as RTPI applications or mobile fare payment systems, actual usage remains limited due to lack of knowledge, unfamiliarity with interfaces, or skepticism about technology reliability and safety. To address this gap, sustained public education and sensitization campaigns must be implemented. These campaigns should be accessible, linguistically appropriate (using Swahili as the primary language), and culturally relevant, targeting passengers across various demographic groups as well as frontline transport personnel such as conductors and drivers. Awareness efforts should leverage radio, television, posters at bus stops, mobile messaging, and social media to explain how to use transport apps, pay digitally, and interpret RTPI displays.

b) Promote inclusive digital access, such as integrating USSD-based transport information services for passengers without smartphones, ensuring that smart mobility solutions do not widen the digital divide.

In addition to awareness-building, digital inclusion must be a foundational design consideration. Not all commuters own smartphones or have access to mobile data, and overlooking this reality risks deepening existing mobility inequalities. To prevent the marginalization of digitally underserved populations, city authorities and developers should integrate USSD-based transport information systems that allow feature phone users to receive route schedules and fare information via simple codes. These low-bandwidth systems have already proven successful in mobile banking and health services across East Africa, and could be adapted to the mobility sector. Such initiatives ensure that digital transport services are universally accessible, rather than exclusive to tech-savvy or high-income groups.

c) Engage operators in co-design processes to ensure that technological solutions reflect their operational realities and concerns, improving buy-in and compliance.

Finally, successful adoption of intelligent mobility systems requires active engagement with transport operators, especially those in the informal sector. Too often, digital interventions are imposed top-down without fully considering the working realities of daladala drivers and conductors. Involving operators in co-design workshops, pilot testing, and user feedback sessions will help ensure that technological tools are practical, acceptable, and aligned with operational workflows. This participatory approach can also increase buy-in, reduce resistance to change, and foster shared ownership of reforms, thereby improving long-term compliance and sustainability of smart transport initiatives.

10.1.4 Strategic Deployment of Intelligent Mobility Solutions

a) Scaling up RTPI systems by initially focusing on high-traffic routes, integrating them with both BRT and daladala services through open-data platforms.

Given the potential of intelligent mobility tools to alleviate congestion and improve service delivery, there is a need for strategic, phased deployment of these solutions across Dar es Salaam's public transport network. A key priority should be the scaling up of Real-Time Passenger Information (RTPI) systems. These systems provide live updates on vehicle arrival times and route availability, thereby reducing uncertainty and smoothing passenger flows at bus stops. The rollout of RTPI should begin with high-traffic corridors, such as the Mnazi Mmoja–Tabata Segerea route, where passenger buildup is most severe. Integrating RTPI into both BRT and daladala services using open-data platforms will ensure interoperability, data-sharing, and system-wide coherence. RTPI displays should be installed at major stops, and linked to mobile applications for broader reach and convenience.

b) Pilot digital fare collection systems on daladala routes in collaboration with mobile payment providers to evaluate feasibility and user response.

In parallel, there is a strong case for piloting digital fare collection systems on select daladala routes. These systems, which can include mobile money payments, NFC cards, or QR-code-based ticketing, help to streamline boarding, eliminate fare disputes, and generate real-time ridership data. Pilots should be conducted in partnership with mobile payment providers such as M-Pesa, Airtel Money, and Tigo Pesa, with negotiated transaction cost subsidies during the initial phase. Pilot evaluation should focus on user satisfaction, transaction security, operational feasibility, and adaptability to the informal sector. Lessons learned can inform guidelines for broader implementation.

c) Invest in integrated platforms that allow passengers to access real-time schedules, fare information, and route planning in one digital ecosystem

Furthermore, there is a need to invest in integrated mobility platforms that bring together multiple digital services into a single user interface. These platforms should allow commuters to check RTPI, calculate fares, plan routes, and make payments—all within a unified ecosystem. Ideally, these platforms would be interoperable with multiple modes of transport (BRT, daladala, and even bike or ride-hailing services) to support end-to-end trip planning. Government bodies such as LATRA, in collaboration with private tech developers, should prioritize the development of such systems with open APIs to allow innovation while maintaining regulatory oversight. This level of integration not only improves the user experience but also strengthens the planning capabilities of transport authorities by consolidating data and offering a holistic view of urban mobility dynamics.

10.2 Conclusion

This study set out to examine how intelligent mobility solutions can be leveraged to alleviate passenger overcrowding at commuter bus stops in Dar es Salaam, Tanzania, a city experiencing rapid urban growth, evolving travel patterns, and mounting pressure on its public transport system. The research was grounded in a mixed-methods approach, incorporating passenger surveys, interviews with institutional stakeholders, field observations, and geospatial analysis. This methodology enabled a holistic understanding of the structural, operational, and behavioral dimensions that contribute to congestion at bus stops. The findings revealed a dynamic and interconnected web of factors, ranging from physical infrastructure limitations and fragmented institutional frameworks to informal operating practices and commuter behavior, that collectively shape the commuter experience in the city.

A key insight from the study is that while digital interventions such as Real-Time Passenger Information (RTPI) systems and mobile fare payment tools offer significant promise, their effectiveness remains constrained by foundational challenges. These include inadequate infrastructure at bus stops, absence of predictable scheduling (particularly in the daladala sector), low digital literacy among segments of the commuting population, and insufficient institutional capacity to coordinate and enforce smart transport policies. These limitations underscore the fact that technology alone cannot resolve passenger congestion unless deployed within a supportive environment that includes physical infrastructure, strong regulatory backing, behavioral adaptation, and inclusive access to digital tools.

The research therefore affirmed the need for a systems-oriented approach to urban mobility planning, one that recognizes and integrates the multiple interdependencies that influence transport outcomes. The conceptual framework used in this study, grounded in Systems Theory and the Technology Acceptance Model (TAM), proved particularly effective in articulating these interdependencies. Systems Theory illuminated the structural feedback loops among scheduling, queuing dynamics, and commuter coping mechanisms, while TAM highlighted the importance of user perceptions, trust, and ease of use in driving technology adoption. Together, these frameworks supported a nuanced analysis of both the potential and the limitations of intelligent mobility solutions in a context like Dar es Salaam.

Furthermore, the study’s emphasis on inclusive innovation is particularly relevant for Sub-Saharan African cities, where the coexistence of formal and informal transport systems poses unique challenges for technology integration. Intelligent mobility should not be approached as a purely technical solution, but rather as a catalyst for broader transformation, requiring institutional reform, user empowerment, community engagement, and data-driven planning. The recommendations provided in this study, ranging from the rollout of RTPI systems and contactless fare payments to the establishment of inter-agency coordination platforms and data hubs, are intended to provide a roadmap for such inclusive and systemic reform.

In conclusion, the transformation of urban public transport in Dar es Salaam will not be achieved through isolated, one-off interventions. It demands a coordinated and multi-dimensional strategy that bridges the gap between infrastructure and information, between policy ambition and implementation, and between commuter needs and operator realities. As cities like Dar es Salaam continue to grow, the pressure on transport systems will intensify, making the need for intelligent, equitable, and sustainable mobility systems not only timely but imperative. By embracing a collaborative and systems-based approach, Tanzania can not only alleviate existing commuter challenges but also lay the foundation for future-ready urban mobility that is smart, inclusive, and resilient.

REFERENCES

AC Group. (2019). *Tap&Go: Transforming Kigali's Transport*. Kigali: AC Group.

African Development Bank (AfDB). (2015). *Tanzania Dar es Salaam Bus Rapid Transit System Project – Phase 2 Appraisal Report*. Access here

Axhausen, K. W., & Gärling, T. (1992). Activity-based approaches to travel analysis: conceptual frameworks, models, and research problems. *Transport Reviews*, *12*(4), 323–341. Access here

Bafana, B. (2020). Smart mobility solutions in Africa's urban transport. *Africa Renewal Journal*, 34(2), 19–24.

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy, 15*(2), 73–80.

Banister, D. (2018). Inequality in transport. *Transport Reviews*, 38(4), 467–491.

Behrens, R., McCormick, D., & Mfinanga, D. (Eds.). (2016). *Paratransit in African cities: Operations, regulation and reform*. Routledge.

Behrens, R., McCormick, D., & Mfinanga, D. (2021). *Paratransit in African cities: Operations, regulation, and reform*. Routledge.

Benevolo, C., Dameri, R. P., & D'Auria, B. (2016). Smart mobility in smart city: Action taxonomy, benefits and challenges. *Transportation Research Procedia, 3*, 111–118.

Barter, P. A. (2002). Transport dilemmas in dense urban areas: Examples from Eastern Asia. *Third World Planning Review, 24*(3), 307–327.

Ben-Akiva, M., & Bowman, J. L. (1998). Activity-based travel demand model systems. *Transport Systems Planning and Operations*, 35(3), 11–30.

Bhat, C. R., & Koppelman, F. S. (2002). Activity-based modeling of travel demand. In *Handbook of Transportation Science* (pp. 39–65). Springer.

Bina, M., & Biassoni, F. (2023). Travel experience and reasons for the use and nonuse of local public transport: A case study within SaMBA. *Sustainability*, 15(24), 16612.

Cervero, R. (2013). Informal transport in the developing world. *United Nations Human Settlements Programme (UN-HABITAT).*

Chengula, D., & Kombe, K. (2017). Assessment of the effectiveness of the Dar Es Salaam Bus Rapid Transit (DBRT) system. *International Journal of Sciences: Basic and Applied Research*, 36, 10–30.

Chong, S., & Tan, K. (2022). Integrating land use and transport planning in Singapore. *Urban Studies Journal*, 59(4), 723–740.

DART. (2008). *Dar Rapid Transit (DART) Project Master Plan*. Dar es Salaam: Prime Minister's Office – Regional Administration and Local Government.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.

Department for Transport (DfT). (2021). *Inclusive transport strategy: Achieving equal access for all*.

Docherty, I., Marsden, G., & Anable, J. (2018). The governance of smart mobility. *Transportation Research Part A: Policy and Practice*, 115, 114–125.

Elassy, M., Al-Hattab, M., Takruri, M., & Badawi, S. (2024). Intelligent transportation systems for sustainable smart cities. *Transportation Engineering*, 16, 100252.

Erlang, A. K. (1909). The theory of probabilities and telephone conversations. *Nyt Tidsskrift for Matematik*, 20, 33–39.

Gakenheimer, R. (1999). *Urban mobility in the developing world*. Transportation Research Part A: Policy and Practice, 33(7-8), 671–689

GEF. (2019). *Sustainable transport in Mexico City*.

Geels, F. W. (2012). A socio-technical analysis of low-carbon transitions. *Energy Research & Social Science*, 1, 24–32.

Gössling, S. (2020). Integrating ICT into sustainable urban transport: The role of smart mobility. *Journal of Transport Geography*, 82, 102555.

Gross, D., Shortle, J. F., Thompson, J. M., & Harris, C. M. (2018). *Fundamentals of queuing theory* (5th ed.). Wiley.

Harrison, M. (2021). Public transport reform in Rwanda: Lessons from Kigali. *Transport Policy Review*, 15(3), 112–128.

Hickman, R., Chen, C. L., Chow, A., & Saxena, S. (2019). Improving interchanges in urban transport. *Case Studies on Transport Policy*, 7(1), 41–50.

Hillier, F. S., & Lieberman, G. J. (2021). *Introduction to operations research* (11th ed.). McGraw-Hill.

Hossain, M., & Muromachi, Y. (2012). *A development approach for real-time traffic information system for Dhaka city: Towards improving traffic condition and mitigating traffic congestion*. Procedia - Social and Behavioral Sciences, 43, 490–499.

Ibrahim, A. N. H., Borhan, M. N., Zakaria, N. A., & Sainal, S. K. (2019). Effectiveness of commuter rail service in Kuala Lumpur. *International Journal of Engineering & Technology*, 1(1.2), 50–55.

Japan International Cooperation Agency (JICA). (2008). *Transport policy and system development master plan*.

Japan International Cooperation Agency (JICA). (2018). *Dar es Salaam urban transport master plan*. Dar es Salaam, Tanzania.

JICA. (2018). *Dar es Salaam transport policy and system development master plan*. Dar es Salaam, Tanzania.

Jones, T., & Smith, R. (2022). Data-driven decision making in public transport: The TfL case. *Journal of Transport Policy*, 19(3), 231–245.

Kamau, J., Karanja, P., & Mwangi, T. (2021). Formalizing informal public transport in Nairobi's Matatu sector. *Urban Mobility Studies in Africa*, 5(1), 67–82.

Kanyama, A., Carlsson-Kanyama, A., Lindén, A.-L., & Lupala, J. (n.d.). An analysis of the situation in Dar-es-Salaam from an institutional coordination perspective. In *Urban Transport Development* (pp. 65–85). Springer.

Kemwita, E. F., Kombe, W. J., & Nguluma, H. M. (2023). Land acquisition in flood-risk informal settlements in Dar es Salaam. *African Journal on Land Policy and Geospatial Sciences*, 6(1), 188–208. https://doi.org/10.48346/IMIST.PRSM/ajlp-gs.v6i1.35236

Kiunsi, R. B. (2013). A review of traffic congestion in Dar es Salaam from a physical planning perspective. *Journal of Sustainable Development*, 6(2), 94–103.

Kombe, W. J., & Lupala, J. (2019). Governing the city in Africa: The case of Dar es Salaam, Tanzania. In P. Harrison, M. Rubin, & A. Appelbaum (Eds.), *Densifying the city? Global cases and Johannesburg* (pp. 120–136). Edward Elgar Publishing.

Kothari, C. (2004). *Research methodology: Methods and techniques* (2nd rev. ed.). New Age International.

Krishnamurthy, G., Thrivikraman, M., Kuri, J., Dagale, H., Sudhakar, G., & Sanyal, S. (2012). Implementation of a real-time passenger information system. *IEEE Proceedings*.

Land Transport Authority (LTA). (2021). *Enhancing public transport efficiency: Annual report*.

Land Transport Regulatory Authority (LATRA). (2019). *Urban public transport report*. Dar es Salaam, Tanzania.

LATRA. (2020). *Annual report on public transport regulation*. Dar es Salaam, Tanzania.

Litman, T. (2021). *Evaluating transportation equity: Guidance for incorporating distributional impacts in transportation planning*. Victoria Transport Policy Institute.

Liu, L., & Miller, H. J. (2020). Does real-time transit information reduce waiting time? *Transportation Research Part A: Policy and Practice*, 141, 167–179.

Lucas, K. (2011). Transport and social exclusion: Where are we now? *Transport Policy, 20*, 105–113.

Maina, W., & Njagi, L. (2020). RTPI systems and public transport efficiency in Nairobi. *East African Transport Journal*, 12(4), 45–58.

Manirakiza, A. (2022). Improving bus terminals to reduce passenger overcrowding. *RURA Journal of Transport Management*.

Marsden, G., Reardon, L., McArthur, J., & Grange, M. (2020). Big data and transport policy. *Transportation Research Part A: Policy and Practice*, 141, 410–423.

Mchome, E. (2021). Improved business model for commuter bus transport using e-ticketing in Dar es Salaam. *Journal of Building and Land Development*, 22(1), 59–70.

Medhi, J. (2017). *Stochastic models in queuing theory*. Academic Press.

Mganda, V. O. (2017). Adoption of BRT as a means to reduce congestion in Tanzania. *Business Education Journal*, 1(3), 103–295.

Ministry of Infrastructure Development. (2003). *National Transport Policy*. United Republic of Tanzania.

MobiliseYourCity. (2019). *Studies of informal passenger transport reforms in sub-Saharan Africa: Kigali*. https://www.mobiliseyourcity.net

Msigwa, R. (2021). ICT solutions in public transport: Dar es Salaam case study. *Tanzania Journal of Transport Studies*, 9(2), 45–56.

Msigwa, R. E. (2013). Challenges facing urban transportation in Tanzania. *Mathematical Theory and Modelling*, 3(5), 18–26.

Mtega, W. P., & Malekani, A. W. (2009). Analyzing the usage patterns and challenges of telecenters among rural communities: Experience from four selected telecenters in Tanzania. *International Journal of Education and Development using ICT, 5*(2).

Munshi, A. (2022). Formalization of Kigali's public transport. *Urban Mobility Review*.

Nguyen, L. T., Lin, T., & Wahid, R. (2020). Intelligent mobility using real-time data: Singapore case. *Smart Transportation*, 3(2), 101–115.

Papa, E., & Ferreira, A. (2018). Sustainable accessibility and the implementation of urban transport policies: Identifying the barriers to policy change. *Transport Policy, 61*, 134–140.

PLOS ONE. (2023). Special issue on public transportation planning. *PLOS ONE*, 18(5). https://journals.plos.org/plosone/

Porter, G., Abane, A., & Lucas, K. (2020). User perceptions of transport in Ghana and Nigeria. *Transport Policy*, 97, 79–87.

Public Transport Council. (2020). *Dynamic scheduling and passenger flow management*.

Putri, R. A., Rakhmatullah, A. R., & Kusumodewi, D. I. (2022). Characteristics of built environment near TransJogja stops.

RURA. (2021). *Public transport regulations and licensing framework*. Kigali: Rwanda Utilities Regulatory Authority.

Salon, D., & Gulyani, S. (2010). *Mobility, poverty, and gender: Travel 'choices' of slum residents in Nairobi, Kenya*. Transport Reviews, 30(5), 641–657.

Shaheen, S., & Cohen, A. (2013). Carsharing and personal vehicle services: Worldwide market developments and emerging trends. *International Journal of Sustainable Transportation, 7*(1), 5–34.

Shaheen, S., & Cohen, A. (2020). Shared mobility policies in North America. *Transport Policy*, 89, 54–65.

Surface and Marine Transport Regulatory Authority (SUMATRA). (2011). *Study on user needs in public transport in Dar es Salaam*.

Tan, C. K., Chew, D. L., & Wong, Y. D. (2019). Singapore's Smart Mobility 2030. *Research in Transportation Economics*, 77, 100737.

Tirachini, A., Hensher, D. A., & Rose, J. M. (2013). Crowding in public transport systems. *Transportation Research Part A: Policy and Practice*, 53, 36–52.

Transport for London (TfL). (2023). *Annual report: Innovations in public transport*.

UITP. (2021). *Optimizing public transport systems: Case studies*.

UN-Habitat. (2016). *The New Urban Agenda*.

United Republic of Tanzania. (2003). *National transport policy*. Ministry of Transport.

United Republic of Tanzania (URT). (2013). *2012 Population and housing census*. Dar es Salaam, Tanzania.

Watkins, K., Ferris, B., et al. (2011). RTPI systems and passenger waiting times. *Journal of Public Transport Studies*.

World Bank. (2011). *Urban transport and mobility in developing countries*.

World Bank. (2019). *Shifting Mobility Paradigm*. Access here

Zhao, P., Li, S., & Liu, Y. (2018). Unequal accessibility of public transport in urban China: Evidence from Beijing. *Cities, 79*, 100–112.

APPENDICES

Official authorization letter for data collection (Written in Kiswahili)

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

MKOA WA DAR ES SALAAM
Anwani ya Simu:
Simu:2203156/2203158/286371
Barua pepe ras@dsm.go.tz

Unapojibu Tafadhali taja:
Kumb. Na. EA.260/307/02B/312

OFISI YA MKUU WA MKOA,
3 Barabara ya Rashidi Kawawa
S.L.P 5429,
12880 DAR ES SALAAM.

24 Aprili, 2025.

Mkurugenzi wa Jiji,
Halmashauri ya Jiji la Dar es Salaam,
Dar es Salaam.

Yah: **KIBALI CHA KUFANYA UTAFITI**

Tafadhali rejea somo tajwa hapo juu.

2. Ofisi ya Mkuu wa Mkoa wa Dar es Salaam imepokea barua **yenye Kumb. Na. AC.303/327/01 ya tarehe 4 Aprili, 2025** kutoka Chuo Kikuu cha Ardhi ikimtambulisha na ikimwombea kibali cha utafiti **Ndg. Curthbert Njele** katika Halmashauri yako.

3. Mtafiti huyu anafanya utafiti kuhusu **"Matumizi ya Suluhu za Kiakili za Usafirishaji katika Kupunguza Msongamano wa Abiria katika Vituo vya Mabasi ya Mjini."**

4. Kwa barua hii, kibali kimetolewa kuanzia 23 Aprili, 2025 mpaka 30 Mei 2025.

Asante kwa ushirikiano wako.

Emmanuel Msona
Kny: **KATIBU TAWALA MKOA**
DAR ES SALAAM

Nakala: Makamu Mkuu wa Chuo,
Chuo Kikuu cha Ardhi,
S.L.P 35176,
Dar es Salaam.

Ndg. Curthbert Njele

THE UNITED REPUBLIC OF TANZANIA
MINISTRY OF TRANSPORT

LAND TRANSPORT REGULATORY AUTHORITY

LATRA

In replying please quote:
Reff. No: CA.197/313/01A/26

04 April, 2025

Dean
School of Spatial Planning and Social Studies
Ardhi University
P.O Box 35176
<u>DAR ES SALAAM.</u>

Ref: **<u>REQUEST FOR PERMISSION TO CONDUCT AN OFFICIAL INTERVIEW WITH LATRA OFFICER IN CHARGE - DAR ES SALAAM</u>**

Refer to your letter dated 25th March, 2025 on the above heading.

2. The Authority is pleased to inform you that your request has been accepted and permission is granted for your student, Curthbert Njele to conduct an official interview with the Dar es Salaam Regional Officer In-Charge, in order to gather insights for his research on Leveraging Intelligent Mobility Solution in *Alleviating Passengers Overcrowding at Commuter Bus Stops.*

3. An appointment has been scheduled for your Student to meet the Regional Officer In-Charge (can be reached at mobile number **0757 236 394)** at Dar es Salaam Office on **Friday, 11th April 2025, at 0900 hours**.

4. Thank you for your cooperation.

PATELI NGEREZA

For: **<u>DIRECTOR GENERAL</u>**

LATRA Head Office, P.O. Box 1742, 41104 Tambukareli, Dodoma
Tel + 255 262 323 930, E-mail: dg@latra.go.tz , info@latra.go.tz Website: www.latra.go.tz

PASSENGER SURVEY QUESTIONNAIRE

Name of the respondent: ……………………………………

Age: ………………………………………………………..

Contact: …………………………………………………….

Name of the Bus Stop: ……………………………………...

Date of Interview: …………………………………………..

Gender: ☐ Male ☐ Female

Section A: Travel Behavior and Experience

1. How often do you use public transport?
   a) Daily
   b) 2-4 times a week
   c) Once a week
   d) Rarely
2. What is your usual waiting time at the bus stop?
   a) Less than 5 minutes
   b) 5-10 minutes
   c) 10-20 minutes
   d) More than 20 minutes
3. Have you ever experienced overcrowding at this bus stop?
   a) Yes
   b) No
4. If yes, what do you think are the main causes of overcrowding? (Tick all that apply)
   a) High passenger demand
   b) Irregular bus schedules
   c) Poor infrastructure (e.g., small waiting areas)
   d) Lack of real-time passenger information
   e) Poor queue discipline
   f) Limited number of buses
5. How do you usually get information about bus arrival times?
   a) Word of mouth
   b) Observation at the bus stop
   c) Mobile apps
   d) Bus station displays
   e) Social media (WhatsApp, Facebook, etc.)
   f) Other (please specify) ______________
6. How do you typically respond to overcrowding at a bus stop?
   a) Wait patiently for the next bus
   b) Look for alternative transport (e.g., boda-boda, taxi)
   c) Walk to another bus stop
   d) Change travel time to avoid peak hours
   e) Other (please specify) ______________

Section B: Perception of Intelligent Mobility Solutions

7. Are you aware of Real-Time Passenger Information (RTPI) systems?
    a) Yes
    b) No
8. Would you use a mobile application for real-time bus tracking if available?
    a) Yes
    b) No
9. What challenges do you foresee in using real-time transport apps? (Tick all that apply)
    a) Lack of a smartphone
    b) High internet costs
    c) Low awareness of such apps
    d) Unreliable network connection
    e) Preference for traditional transport habits
10. Have you ever used mobile ticketing (digital fare payments) in public transport?
    a) Yes
    b) No
11. If no, what is your main concern regarding mobile ticketing?
    a) Security of digital payments
    b) Limited access to mobile payment platforms
    c) Unfamiliarity with how it works
    d) No interest in cashless payments
12. Are public buses prioritized at the intersections?
    a) Yes
    b) No
13. How effective do you think intelligent solutions (e.g., RTPI, mobile ticketing) can be in reducing congestion at bus stops?
    a) Very effective
    b) Somewhat effective
    c) Not effective
14. What improvements would you suggest to reduce overcrowding at bus stops? (Open-ended)
15. Are you willing to pay more for a fare to get an improved passenger experience at this bus stop?
    a) Yes
    b) No, Why? ………………………………………………….
16. Do you have any additional comments or recommendations regarding public transport in Dar es Salaam?

OFFICIAL INTERVIEW QUESTIONS

(LAND TRANSPORT REGULATORY AUTHORITY: DAR ES SALAAM)

Name of Interviewer: ……………………………………….

Name of Interviewee: ……………………………………….

Designation: ………………………………………………...

Contact (Phone Number): …………………………………..

Date of Interview: …………………………………………...

Section A: Regulatory Framework and Policies

1. What policies are currently in place to manage passenger congestion at bus stops?
2. How does LATRA ensure bus operators (drivers) adhere to passenger safety and operational efficiency regulations?
3. Are there any measures that have been taken to integrate technology into public transport management, and how effective have they been?

Section B: Challenges in Public Transport Management

4. What are the biggest challenges LATRA faces in managing and/or regulating passenger overcrowding, especially at bus stops, and how do you intervene in such challenges?
   Challenges;
   Interventions;
5. How does LATRA collaborate with other stakeholders (e.g., DART, private bus operators, city authorities) to address passenger overcrowding, especially at bus stops?
6. What role does LATRA play in regulating and improving bus scheduling to ensure smoother passenger flow?
7. What are the significant constraints in enforcing transport policies effectively, and how do you think such constraints can be addressed?

Section C: Intelligent Mobility Solutions and Technology Adoption

8. Has LATRA explored the use of intelligent mobility solutions (e.g., real-time passenger information systems, automated fare collection) to manage passenger flow / Overcrowding at commuter bus stops? Yes/No.
   If Yes, Briefly describe the solutions.
9. What are the main barriers preventing the adoption of intelligent mobility technologies in Dar es Salaam's commuter transport system?
10. How can LATRA facilitate the integration of digital solutions to aid smooth passenger flow at bus stops, such as mobile apps for real-time bus tracking and digital ticketing?
11. Has there been any pilot projects in Tanzania or case studies involving technology-driven solutions to address passenger overcrowding? If yes, what were the outcomes?
12. How does LATRA ensure that the implementation of intelligent transport solutions aligns with public transport operators (like drivers) and passenger needs?

(Given the diversities in the context of passengers, e.g. Illiterates, Limited Smartphone ownership, disabled people, probable reluctance of passengers to adopt to new technologies / Intelligent Solutions etc.)

Section D: Recommendations and Future Strategies

13. What policy recommendations would you suggest to improve public transport efficiency and reduce overcrowding at bus stops?
14. How does LATRA strengthen collaboration with technology providers and transport operators to modernize urban mobility? If, now, there is no formal collaboration, how do you think LATRA can best collaborate with Tech providers to enhance urban mobility, especially by improving passenger experiences at bus stops?
15. What role do you think public awareness and passenger behavior play in managing passenger overcrowding at commuter bus stops?
16. Are there any successful international case studies that LATRA identifies as models for improving urban transport in Tanzania? If yes, Kindly mention them.
17. What are LATRA's long-term goals for integrating technology into public transport management, and what steps are being taken to achieve them?
18. Lastly, If any, kindly provide any other additional information including attachments and/or other useful information which you may deem helpful regarding the subject matter.

OFFICIAL INTERVIEW QUESTIONS

TANZANIA NATIONAL ROADS AGENCY: DAR ES SALAAM

Name of Interviewer: ……………………………………….

Name of Interviewee: ……………………………………….

Designation: ………………………………………………...

Contact (Phone Number): …………………………………..

Date of Interview: …………………………………………...

Section A: Road Infrastructure and Traffic Management

1. What role does TANROADS play in the planning and development of road infrastructure for public transport in urban areas like Dar es Salaam?
2. How does TANROADS ensure that road designs accommodate efficient commuter transport operations and reduce passenger overcrowding at bus stops?
3. What are the major infrastructure-related challenges contributing to overcrowding at bus stops?
4. Are there specific road design guidelines for commuter bus stops to improve passenger flow and reduce overcrowding? If Yes, please describe them
5. How does TANROADS collaborate with city authorities like LATRA, Urban Planning Dpt, and transport operators (like drivers) to ensure well-rounded transport infrastructures that best meet user-requirements (i.e Passengers)?

Section B: Public Transport Integration and Traffic Flow

6. How does traffic congestion affect the efficiency of commuter transport, and what strategies are in place to address this challenge?
7. What measures have been implemented to ensure smooth traffic flow around commuter bus stops?
8. What considerations are made when expanding or upgrading roads to accommodate growing commuters demand?
9. How does informal transport modes (e.g., bodabodas) affect traffic congestion, and what infrastructure-based solutions are being considered to manage them?

Section C: Intelligent Mobility Solutions and Technological Integration

11. Has TANROADS explored the integration of intelligent mobility solutions (e.g., smart traffic signals, real-time passenger information systems) to enhance commuter transport efficiency? especially, passengers' experiences? If yes, how
12. What are the main barriers to implementing intelligent traffic management systems in commuter transport infrastructure?
13. Does the current bus stop infrastructure/design support innovative mobility solutions such as digital bus tracking and automated fare collection? If Yes, how? If No, what do you think should be done to equip the current design with the needed technologies/ intelligent solutions?
14. Has there been any pilot projects involving smart transport infrastructure? If Yes, what were the key outcomes?

Section D: Policy, Collaboration, and Future Strategies

15. How does TANROADS coordinate with LATRA, municipal authorities, and transport operators to develop integrated transport solutions?

16. What policy recommendations would you suggest for improving infrastructure to support public transport decongestion?
17. Does TANROADS team up with private sector stakeholders to contribute to more intelligent, more efficient commuter transport infrastructure? If yes, how?
18. Are there successful case studies or international examples that TANROADS considers in planning urban road networks? If yes, kindly state them.
19. What are TANROADS' long-term infrastructure plans to improve public transport efficiency and reduce passenger overcrowding at commuter bus stops?
    20: Lastly, kindly provide any supportive information, including attachments (if any), that you may deem supportive of this study.

OBSERVATION CHECKLIST FOR FIELD DATA COLLECTION

General Information

Observer's Name:	………………………………
Date:	………………………………
Time of Observation:	☐ Morning (5:00 AM - 9:00 AM) ☐ Midday (11:00 AM - 2:00 PM) ☐ Evening (4:00 PM - 8:00 PM)
Location (Bus Stop Name):	………………………………
Weather Condition:	☐ Sunny ☐ Cloudy ☐ Rainy ☐ Windy

1. Passenger Volume and Behavior

S/N	Observation Item	Options
1	Estimated Number of Passengers Waiting at Peak Hour	☐ Less than 10 ☐ 10-30 ☐ 31-50 ☐ More than 50
2	Passenger Queuing Behavior	☐ Orderly ☐ Somewhat organized ☐ Disorganized ☐ Rushing to board
3	Passenger Boarding Behavior	☐ Orderly ☐ Moderate disorder ☐ Significant pushing
4	Passengers Left Behind Due to Full Buses	☐ None ☐ 1-5 per bus ☐ More than 5 per bus
5	Passenger Use of Mobile Phones for Transport Info	☐ Many ☐ Some ☐ None

2. Bus Operations and Frequency

Observation Item	Options
Average Waiting Time for a Bus Arrival	☐ <5 min ☐ 5-10 min ☐ 11-20 min ☐ >20 min
Bus Occupancy Level on Arrival	☐ Empty ☐ Some seats available ☐ Full (standing passengers) ☐ Overloaded
Bus Stop Dwell Time (Time Spent for Boarding & Alighting)	☐ <30 sec ☐ 30 sec - 1 min ☐ >1 min
Bus Schedule Adherence	☐ Consistent ☐ Some delays ☐ Unpredictable

3. Infrastructure and Facilities

Observation Item	Options
Condition of the Bus Stop	☐ Well-maintained ☐ Some wear and tear ☐ Poor condition

Availability of Shelter and Seating	☐ Adequate ☐ Limited ☐ None
Availability of Passenger Information Displays	☐ Digital RTPI ☐ Timetable only ☐ None
Accessibility Features	☐ Ramps & pathways ☐ Pedestrian crossings ☐ None

4. Traffic and Safety Conditions

Observation Item	Options
Traffic Congestion Around the Bus Stop	☐ Smooth ☐ Occasional delays ☐ Frequent jams
Pedestrian Safety Measures	☐ Marked crossings & signals ☐ Poorly maintained crossings ☐ No safety measures
Driver Behavior at the Bus Stop	☐ Proper stopping ☐ Blocks traffic ☐ Doesn't stop fully
Presence of Traffic/Transport Officials	☐ Regularly present ☐ Occasionally present ☐ Not present

COMMUTER BUS DRIVER QUESTIONNAIRE

Name of the respondent (driver): ……………………………………

Age: ………………………………………………………..

Contact: …………………………………………………….

Name of the Bus Stop: ……………………………………...

Bus registration No: ………………………………………...

Date of Interview: …………………………………………..

Gender: ☐ Male ☐ Female

Section A: Daily Operations and Challenges

1. What are the peak hours for passenger congestion on your route? (Tick all that apply)
   a) Early morning (5:00 AM - 9:00 AM)
   b) Midday (11:00 AM - 2:00 PM)
   c) Evening (4:00 PM - 8:00 PM)
2. How often do you experience (see) overcrowding at bus stops?
   a) Always
   b) Frequently
   c) During peak hours
   d) Rarely
3. What do you think are the main causes of overcrowding at bus stops? (Tick all that apply)
   a) High passenger demand
   b) Irregular bus schedules
   c) Limited number of buses
   d) Poor passenger queuing discipline
   e) Lack of real-time passenger information
   f) Inadequate bus stop infrastructure
   Other (Please specify) …………………………………………………….
4. How do you manage overcrowding when your bus is already full?

a) Stop and explain to passengers

b) Skip the stop when the bus is full

c) Allow extra passengers to board beyond capacity

d) Other (please specify) ______________

5. What are the main challenges you face while operating a bus in crowded areas? (Tick all that apply)

a) Difficulty in picking up and dropping off passengers

b) Traffic congestion delaying trips

c) Pressure from passengers to overload the bus

d) Poor road conditions

e) Lack of proper bus stops

f) Lack of coordination with other buses

Other (Please Specify)

Section B: Awareness and Use of Intelligent Mobility Solutions

6. Have you heard of Real-Time Passenger Information (RTPI) systems?

a) Yes

b) No

7. Have you used intelligent mobility solutions (such as mobile apps, digital schedule displays, or GPS tracking) in public transport?

a) Yes

b) No

8. If Yes, Where and How ………………………………………………………………..

9. If No, Why ……………………………………………………………………………….

10. Would you be willing to adopt and/or use intelligent mobility solutions (such as mobile apps, digital schedule displays, or GPS tracking) if provided?

a) Yes

b) No

11. If No, Why ……………………………………………….

12. What challenges do you think could hinder the adoption of intelligent mobility solutions? (Tick all that apply)

a) Lack of smartphones or digital literacy

b) Unreliable internet connectivity

c) Resistance from bus operators or drivers

d) High costs of implementation

e) Lack of government or stakeholder support

Other (Please Specify) ………………………………………………………………………….

13. How do you think intelligent solutions can improve bus operations and reduce congestion?

Section C: Recommendations and Additional Comments

14. What improvements would you suggest to reduce overcrowding at bus stops?
15. Do you have additional comments or recommendations regarding public transport operations in Dar es Salaam? If yes, please state them.