

## **GREEN TRANSPORTATION: A CONCEPTUAL FRAMEWORK IN CAMPUS-TO-CITY INTEGRATED PUBLIC TRANSPORT**

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### **ABSTRACT**

The importance of campus-to-city integrated public transport lies in its ability to reduce reliance on private vehicles, decrease traffic congestion, and lower greenhouse gas emissions, thereby significantly contributing to climate action. However, comprehensive strategies for enhancing campus-to-city integrated public transport are still limited. This study aims to identify key areas of intervention and indicators for effective analysis of campus-to-city integrated public transport through an integrative literature review. The goal is to provide a conceptual framework that scholars and practitioners can apply in empirical studies across various institutions. The results from this conceptual analysis are also suitable for educational purposes and future research at Politeknik Sultan Idris Shah Sabak Bernam. This framework supports Sustainable Development Goals (SDGs) 11 (Sustainable Cities and Communities) and 13 (Climate Action), promoting sustainable urban mobility solutions and contributing to broader goals of sustainable development.

**Keywords:** Green Transportation, Campus to -city integrated, public transport, conceptual framework.

### **1. INTRODUCTION**

Green transportation, encompassing a range of eco-friendly transport modes such as electric vehicles, public transit, cycling, and walking, plays a critical role in mitigating climate change and reducing urban pollution. The transportation sector is a significant contributor to global greenhouse gas (GHG) emissions, accounting for approximately 14% of the total emissions, with the majority stemming from road transport. Transitioning to green transportation is essential for achieving global climate targets, improving air quality, and enhancing public health. There are the main discussion related to the green transportation in literature, for example, climate change mitigation. The primary importance of green transportation lies in its potential to significantly reduce GHG emissions (Saba & Bilal, 2023). Traditional vehicles rely heavily on fossil fuels, releasing carbon dioxide (CO<sub>2</sub>) and other harmful pollutants into the atmosphere. Electric vehicles (EVs), for instance, produce zero tailpipe emissions and, when powered by renewable energy sources, can greatly diminish the carbon footprint of transportation (Ghosh, 2020). Additionally, promoting public transit, cycling, and walking reduces the number of vehicles on the road, leading to lower emissions overall (IEA, 2020). Besides, urban areas suffer from high levels of air pollution, primarily due to vehicle emissions. Pollutants such as nitrogen oxides (NO<sub>x</sub>), particulate matter

(PM), and volatile organic compounds (VOCs) contribute to respiratory diseases, cardiovascular problems, and premature deaths. Implementing green transportation solutions can improve air quality by reducing these harmful emissions. For example, the increased use of EVs and hybrid vehicles reduces NOx and PM emissions, while investments in cycling infrastructure and pedestrian-friendly urban planning encourage cleaner modes of transport (WHO, 2016). Apart from environmental benefits, green transportation also offers economic and social advantages. It can lead to cost savings for individuals and governments through reduced fuel consumption and lower healthcare costs associated with pollution-related illnesses. Moreover, it promotes healthier lifestyles and can improve the quality of life by creating more livable urban environments (ICLEI, 2021).

Despite various government initiatives aimed at improving public transportation, one of the most pressing issues remains is on improving strategies of an integrated public transport system (Nguyen, 2020; Brohi et al, 2018), including concerning the campus-to-city connection. This gap in integration leads to significant inconvenience and inefficiency for students, faculty, and staff who rely on public transport for their daily commute. While efforts have been made to enhance individual transport modes, the seamless connection between these modes is often missing, resulting in disjointed travel experiences. The primary concern lies in the coordination and synchronization of different transport modes. Irregular timetables and poorly coordinated schedules cause long waiting times and missed connections, which can be particularly frustrating for students who have tight schedules and need to commute between classes, internships, and other activities. Additionally, the lack of direct links between campuses, city centers, and key destinations like airports exacerbates the problem, often requiring multiple transfers that add unnecessary time and complexity to journeys. Another critical issue is the infrastructure supporting these transport systems. Many campuses lack adequate facilities such as sheltered waiting areas, secure bike storage, and accessible paths, which are essential for encouraging public transport use.

Furthermore, the absence of a unified ticketing system complicates travel, as passengers have to navigate different ticketing processes and pricing structures, making the system less user-friendly and more expensive. Environmental and financial sustainability are also at risk due to the inefficiencies of the current system. Overcrowding during peak times leads to uncomfortable and sometimes unsafe conditions, while underutilization during off-peak hours results in wasted resources and higher operational costs. These inefficiencies not only undermine the environmental benefits of public transport but also strain financial resources that could be better allocated. Safety and security are additional concerns, particularly for students traveling late at night or through less monitored areas. Ensuring safe and secure travel is paramount, yet many existing systems fall short in providing adequate measures to protect passengers. Given these multifaceted issues, it is clear that a comprehensive and integrated approach to public transport is necessary. This involves not only improving the infrastructure and coordination of existing transport modes but also implementing policies that promote seamless connectivity, real-time information access, and integrated ticketing systems. Therefore, this study will discuss on more efficient, sustainable, and user-friendly public transport system that better serves the needs of students and the broader community.

## **2. LITERATURE REVIEW**

### **2.1 Definition and Key Components of Green Transportation**

Green transport encompasses transport methods that have a negligible ecological footprint and are capable of being maintained over an extended period of time. This includes a range of tactics and technology designed to lower carbon emissions, reduce dependence on fossil fuels, and encourage

energy efficiency. Green transportation encompasses several sustainable approaches such as public transit systems, electric and hybrid automobiles, cycling, walking, and the utilisation of renewable energy sources to power transportation systems. Table 1 summarize the definition of the green transportation. These points collectively emphasize the multifaceted approach of green transportation, which encompasses reducing environmental impacts, promoting sustainable planning, minimizing resource consumption, utilizing eco-friendly practices, and integrating environmental considerations into transportation planning for overall urban sustainability.

**Table 1: Definition of Green Transportation**

Reference	Definition
Litman, (2020)	modes of transport that have a minimal environmental impact and are sustainable in the long term. This encompasses a variety of strategies and technologies aimed at reducing carbon emissions, decreasing reliance on fossil fuels, and promoting energy efficiency.
Banister, (2008)	An approach to transportation planning that emphasizes sustainability, aiming to reduce greenhouse gas emissions and environmental impact while promoting efficient and equitable mobility.
Holden & Linnerud (2011)	Methods of transportation that reduce the consumption of non-renewable resources, decrease pollution, and contribute to the sustainable development of urban areas.
Zhang & Batterman, (2013)	The use of environmentally friendly vehicles and practices, such as electric vehicles, public transit, cycling, and walking, to minimize environmental harm and enhance urban livability.
Givoni, (2014)	A comprehensive approach that integrates environmental considerations into transportation planning, focusing on reducing ecological footprints and fostering sustainable urban growth.

In addition, in the pursuit of sustainable urban mobility and the goal of minimising environmental impact, governments worldwide have devised inventive strategies and exemplary methods in green transportation. These practices include a diverse array of measures, ranging from cutting-edge technical solutions to complete legislative frameworks designed to decrease carbon emissions and improve the effectiveness of public transport networks. Through analysing the achievements and knowledge acquired from many countries, have best practices to execute environmentally-friendly transportation programmes. Nations such as Norway (Yang, Liu, Yang, & Lu, 2023; Mikalsen, 2021), Germany, Japan, and the Netherlands (Sun et al., 2020) have taken the lead in embracing and incorporating environmentally friendly transportation technologies and legislation. Norway's emphasis on electric vehicles and well-developed hydropower infrastructure offers a model for effectively utilising renewable energy in the transportation sector. German's dedication to implementing high-speed rail systems and strict emissions controls demonstrates the capacity to combine public transit and environmental policy. Japan's allocation of funds towards electric and hydrogen fuel cell vehicles underscores the significance of technology advancement in attaining sustainable transportation objectives. Meanwhile, the Netherland' focus on developing bike infrastructure and urban planning illustrates the influence of cultivating a culture centred around sustainable mobility. Table 2 present the summary the best practices of green transportation.

**Table 2: Best Practices of Green Transportation**

Research Direction	Electric Vehicles	Renewable Energy	Public Transport	Cycling Culture	Innovation Technology	Urban Planning
Country						
Norway	√	√				
The Netherlands			√	√		
Denmark		√	√			
Germany		√	√			
Sweden					√	√
Japan	√		√			
Singapore			√			
Finland			√			
Canada			√			√

## 2.2 Integrated Public Transport

Integrated public transport systems are increasingly recognized as vital components of urban mobility solutions worldwide. The concept involves the seamless coordination of various transportation modes, such as buses, trains, rickshaws, bicycles, and micromobility options, to create a cohesive and efficient network. This integration aims to enhance convenience for users, reduce dependency on private vehicles, alleviate traffic congestion, and promote sustainable urban development. For example, (Aziz, et al, 2018) investigates the potential of integrating well-organized rickshaws with trained drivers into Lahore's mass transit system. The research highlights the benefits of fare integration and improved convenience for the public. The findings suggest that such integration can complement existing transport modes, offering a practical solution to enhance urban mobility and reduce traffic congestion. Maruyama & Seo, (2023) introduces a multimodal route choice model that allows users to combine Fixed and Flexible Public Transport services. Implemented in the Amsterdam network through an agent-based simulation framework, the study shows a decrease in the share of Fixed Public Transport and an overall increase in Public Transport usage when these services are combined. However, the study also points out the minimal improvements in Level-of-Service for a small fleet size, highlighting the challenges in integrating Fixed and Flexible services effectively. Besides, micromobility, such as e-scooters and e-bikes, is a fast-growing urban mobility trend aiming to reduce reliance on private vehicles (Oeschger, Carroll, & Caulfield, 2020). Research lacks quantification of the impacts of micromobility and public transport integration, with modal shift being the most studied impact. Safety regulations for micromobility and the environmental impact of electric micro-vehicles are key topics of debate in the literature. Sustainable urban mobility is a key focus, with research exploring user preferences for different transport options. The concept of Mobility-as-a-Service (MaaS) is analyzed in the context of private cars and public transportation usage in Seoul. Intermodal urban mobility, including intermodal hubs of urban public passenger transport, is a topic of interest for enhancing transportation services.

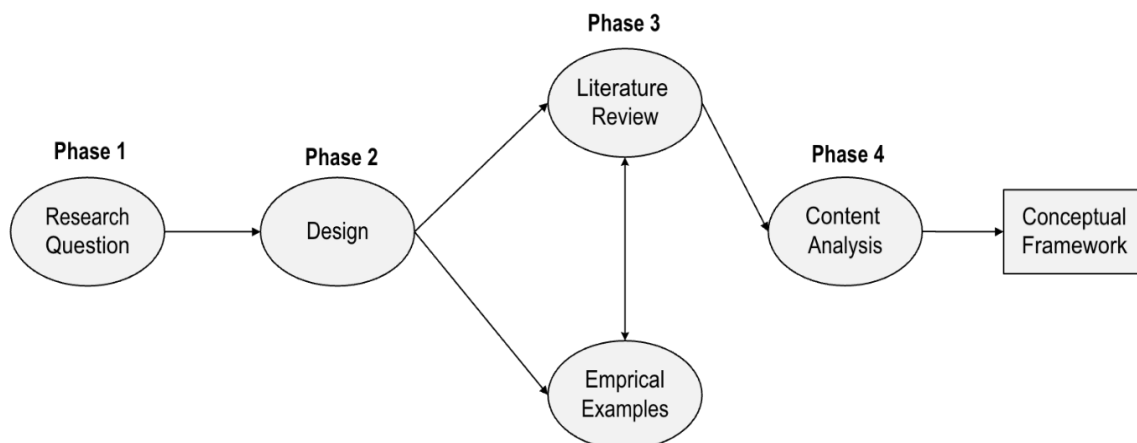
On the other hand, Integrated public transport systems enhance urban mobility by coordinating various transportation modes, improving convenience, reducing traffic congestion, and promoting sustainability. University campuses, like urban areas, face similar challenges but on a smaller scale, requiring coordinated transport services and fare integration. Adapting these broader strategies to campus settings can significantly improve mobility and sustainability for students, faculty, and staff. Crotti, Grechi, & Maggi, (2022) focuses on the commuting habits of university populations,

particularly at a suburban college in Italy, emphasizing the importance of sustainable transport modes. It highlights the role of public transport proximity in influencing commuting mode choices, such as car, bus, train, and carpooling, based on spatial trip factors. The study uses a multinomial logit model to analyze determinants of commuting modes and the dominance of cars, considering factors like age, gender, trip frequency, and length. The research aims to provide insights for policymakers to implement effective sustainable transport policies, like parking fees and improving public transit accessibility.

The study focuses on addressing mobility issues in college campuses caused by an increase in private vehicle usage, proposing sustainable mobility policies for the University of Cantabria in Spain (Luigi et al., 2014). The research suggests implementing strategies like managing parking spaces, introducing a bike-sharing system, and operating a shuttle bus from a stadium car park on the campus limits to encourage sustainable transportation options. Fernandes, Sousa, Macedo, & Coelho, (2019) focused on analyzing various mobility scenarios' impact on traffic performance, conflicts, pollutants, and emission-related costs on a University Campus. Different scenarios were studied, such as replacing traffic lights with roundabouts, introducing a new campus access, enhancing walkability, and adding speed humps. Implementing a new direct access to the campus showed reductions in costs, local pollutants, number of stops, and traffic conflicts, but it may lead to additional conflicts within the campus.

### 3. METHODOLOGY

This study employs a structured methodology shown in Figure 1 to develop a conceptual framework based on Piva, (2024) for integrating sustainability, innovation, and policy in green transportation. The methodology comprises several key steps: defining the research question, designing the study, conducting a comprehensive literature review, performing content analysis, providing empirical examples, and synthesizing findings into a cohesive framework.



**Figure 1: Overview of the Conceptual Framework Methodology**

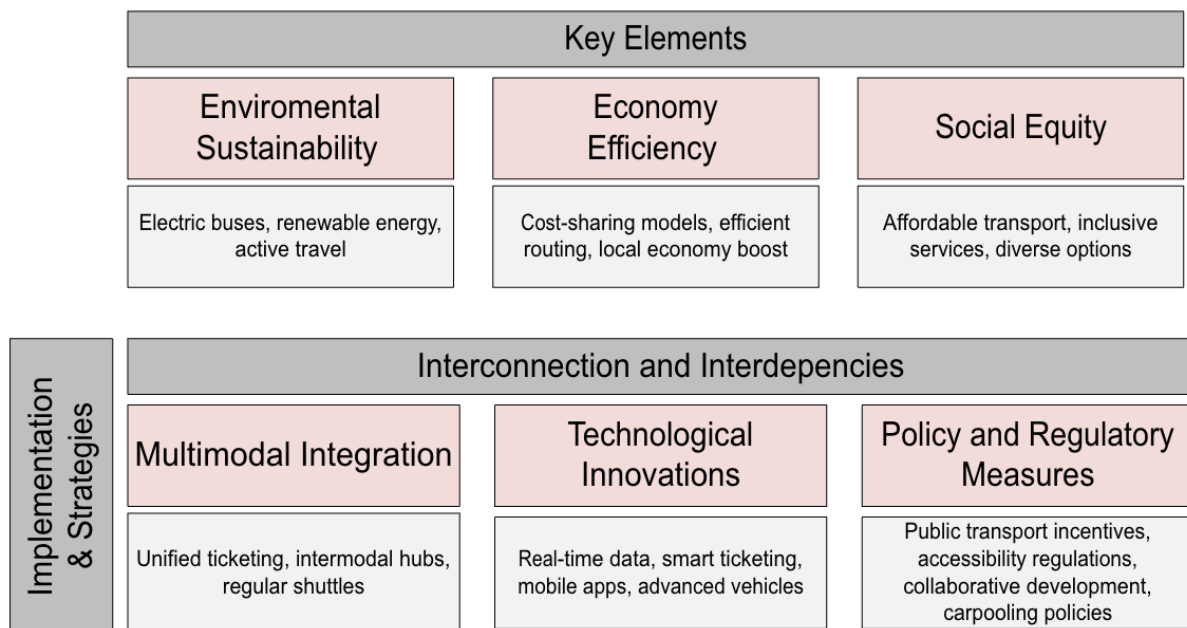
To begin with, the research question focused on integrating sustainability, innovation, and policy within green transportation systems: “What are the key factors influencing the effectiveness of integrated public transport systems between campuses and city centers?” This question guided the research design. A comprehensive literature review was conducted using academic databases, targeting keywords such as “green transportation,” “integrated transport,” “transportation policy,” and “innovation in transportation.” Relevant studies were selected based on inclusion and exclusion criteria, then organized into themes to identify key findings and gaps. Content analysis revealed

patterns and relationships, supported by a coding scheme developed from the research question and themes.

#### 4. CONCEPTUAL FRAMEWORK

##### 4.1 Conceptual Framework for Green Transportation in Integrated Public Transport: Politeknik Sultan Idris Shah Sabak Bernam

The concept of mobility is closely linked to achieving Sustainable Development Goals (SDGs) 11 (Sustainable Cities and Communities) and 13 (Climate Action). From the review, Figure 1 presented the conceptual framework for integrating public transport between campus and city to address key elements of environmental sustainability, economic efficiency, and social equity.



**Figure 2: A Conceptual Framework in Campus-to-City Integrated Public Transport**

The foundational elements are interconnected and dependent on effective implementation strategies such as multimodal integration, technological innovations, and policy and regulatory measures. Environmental sustainability is achieved through the adoption of electric buses, the utilization of renewable energy sources, and the promotion of active travel modes like cycling and walking. Economic efficiency is enhanced by developing cost-sharing models with local authorities and private partners, optimizing transport routes to reduce operational costs, and stimulating local economic activities by providing reliable transport links. Social equity focuses on ensuring that transportation options are accessible and affordable for all members of the campus community, including students, faculty, and staff, by offering inclusive services and diverse transport options. To implement this framework, Politeknik Sultan Idris Shah Sabak Bernam can pursue multimodal integration through the development of unified ticketing systems that allow seamless travel across different modes of transport, the establishment of intermodal hubs to facilitate easy transfers between buses, trains, and bicycles, and the provision of regular shuttle services connecting the campus with nearby transport hubs and city centers. Technological innovations play a critical role in enhancing the transport system's efficiency and user experience by providing real-time data on transport schedules, implementing smart ticketing solutions for contactless payments, and developing mobile applications to assist users in navigating the transport network. Policy and regulatory measures are essential to support these initiatives, including incentives for public

transport use, regulations to ensure transport accessibility and affordability, and collaboration between government agencies, transport providers, and the community. These measures collectively aim to create a sustainable, efficient, and equitable transport system that enhances mobility and contributes to the overall quality of life for the campus community.

## 5. CONCLUSION

In conclusion, the conceptual framework for campus-to-city integrated public transport underscores the importance of aligning environmental sustainability, economic efficiency, and social equity. By adopting multimodal integration, leveraging technological innovations, and implementing robust policy and regulatory measures, institutions such as Politeknik Sultan Idris Shah Sabak Bernamm can create a transport system that not only meets the diverse needs of its community but also contributes to broader sustainability goals. The research highlights the factors influencing the effectiveness of integrated public transport systems, including the adoption of electric buses, renewable energy, and active travel modes. Economic strategies such as cost-sharing models and optimized routing, coupled with social equity measures ensuring accessibility and affordability, are essential for a holistic approach. The synthesis of literature, provides a comprehensive understanding of the challenges and opportunities in implementing green transportation solutions.

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