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School of Transportation Sciences

Master of Transportation Sciences

Master's thesis

Ho Chi Minh city school bus stops allocation based on student demand using GIS

Thanh Dai Phuc Tran

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

SUPERVISOR :

Prof. dr. ir. Tom BELLEMANS

SUPERVISOR :

Dr. Dinh Vinh Man NGUYEN

2024
2025

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STATEMENT OF ASSURANCE

This is to affirm that the research and findings presented have been conducted with integrity, diligence, and in full accordance with the applicable academic standards. The research was carried out in strict adherence to the principles of the research process, ensuring the objectivity and validity of the findings. All data sources and references have been cited appropriately.

In line with the academic integrity framework, I acknowledge the support and guidance provided by my thesis advisors, Prof. dr. Tom Bellemans & Dr. Nguyen Dinh Vinh Man. Their invaluable mentorship and expertise were crucial throughout the research process, ensuring that the methodology, data, and conclusions meet the required standards of reliability and academic.

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1. Introduction

1.1. Context & Problem Statement

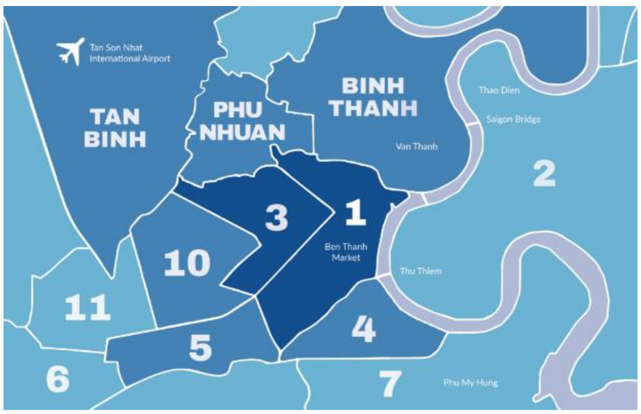
Urbanization is recognized as a feature of modernization impact on social, economic, and environment when more inhabitants come to live in the city (Phetkeo Poumanyvong, 2012), (National Geographic Society, 2023). World Bank (2023) also stated 4.4 billion people which is approximately 56% of the whole world's population.

Population growth also brings challenges to transportation besides basic services and jobs, and potential conflicts between people living in urban areas compared to others are strongly interlinked, and urban growth and transport present closely associated issues. Urban development is attracted by transport infrastructure, while, conversely, the increase in travel demand caused by urban growth and population results in a heightened need for transport infrastructure (Chung, 2017).

(Viet Visit, 2024)

Figure 1. Ho Chi Minh Location in Vietnam

Vietnam or Ho Chi Minh specifically are among high rapidly urbanized, also face the same issue of transportation while experiencing significant urbanization, especially in peak hour which including school time (Biên, 2022). Regarding population, Ho Chi Minh city is the most populated administrative unit in the country, so the population density of Ho Chi Minh city is very high. The population density of the city is only lower than that of Hanoi and 10.7 times higher than that of the national average. In the inner city, it is only 21.1% of the city area, but it is the residence area of 81.7% of the population (2019) Xuan Phuong Nguyen. According to the Director of the Ho Chi Minh City Department of Education and Training, the 2022-2023 school year saw approximately 1.7 million students, an increase of 21,897 from the previous year. With an average of 2 students per personal vehicle, around 850,000 vehicles hit the roads during school hours. The high number of personal vehicles, including space-consuming cars, contributes to congestion and chaos around schools. (Thư, 2022)



(Viet Visit, 2024)

Figure 2. Ho Chi Minh Inner Districts Location

In Ho Chi Minh City, the school bus system is only partially extended to the outer city, leaving the inner city underserved (Oanh, 2020). The door-to-door services for students is impractical due to high operational costs and budget constraints. It is better and feasible to establish a set of predetermined stops to efficiently gather students and transport. However, the implementation of such bus stops which is an important aspect to enhance the school bus service, has not been effectively addressed in Ho Chi Minh City. As a result, the Ho Chi Minh City's inner districts lack strategically placed bus stops that can meet student demand.

1.2.Research Objectives

The primary objective of this research is to propose bus stop locations for High School students in Ho Chi Minh City's Inner Districts based on student population, utilizing Geographic Information Systems (GIS)

1.3. Research Questions

What are the current distribution patterns of High School students in Ho Chi Minh City's inner districts?

How can GIS-based analysis determine bus stop locations to maximize accessibility for High School students?

What factors, including student density and walking distance, should be prioritized to ensure the proposed bus stops meet the needs of High School students?

1.4. Research Object

The primary object of this research is High School students in Ho Chi Minh City's Inner Districts which are District 1 and 3.

1.5. Research Area

The research primarily focuses on Ho Chi Minh City's inner districts, specifically Districts 1 and 3. However, the study also includes a discussion and recommendations at its conclusion, suggesting ways to expand the proposed solutions to a larger area, particularly by enhancing the connection between school bus stops and other modes of public transportation.

2. Literature review

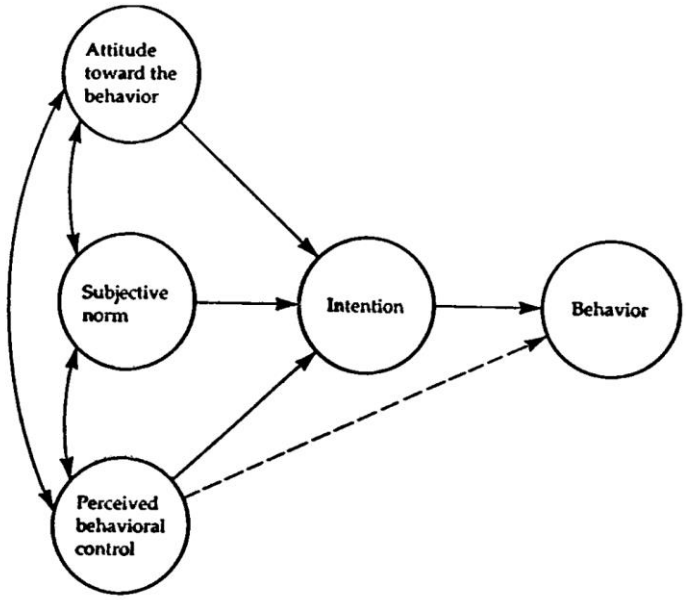
2.1. Ho Chi Minh City's inner district background

Districts 1 and 3 in Ho Chi Minh City play central roles in the city's public transportation landscape due to their high population density and extensive urban development. District 1, known as a commercial and cultural hub, spans approximately 7.7 square kilometers with a population of around 205,000, while District 3 covers about 4.9 square kilometers with a population density of closely 40,000 people per square kilometer (Rever, 2020). Both districts exhibit high population densities, with District 3 reaching some of the city's highest levels due to concentrated residential and commercial activities. District 1 and District 3 hosts numerous educational institutions, including about 12 High School (Phòng tổ chức cán bộ, 2025)

In Ho Chi Minh City, the local government plans to implement Geographic Information Systems (GIS) to manage school allocations for 10th-grade students, which is the entry grade of High School in Vietnam. (Thanh, 2024). This initiative aims to assign students to schools nearest to their residences, supporting the goal of reducing travel distances and enhancing convenience for students and families. Schools in HCMC also prioritize enrolling students who live in proximity to the school, aligning with policies that promote localized education and community-based schooling (Sở Giao Dục và Đạo Tạo, 2024).

2.2. Theoretical Framework

The Theory of Planned Behavior (TPB), developed by (Ajzen, 1991), is a comprehensive framework for predicting and understanding human behavior based on attitudes, subjective norms, and perceived behavioral control. This theory has been extensively used in transportation studies to analyze travel decisions. For instance, in research on young drivers' use of (Qi Zhong, 2024), an extended TPB model included additional variables such as descriptive norms and perceived risks, enhancing its explanatory power. In the context of allocating school bus stops in this research, TPB offers a theoretical basis for understanding how students' and parents' attitudes toward school bus usage, social expectations, and perceptions of ease or difficulty in accessing bus stops influence their behavior.



(Ajzen, 1991)

Figure 3. Theory of planned behavior

The spatial optimization model is a powerful method used to solve location-allocation problems, particularly in urban planning and infrastructure management. It is commonly applied in situations where resources or facilities, such as public services, need to be allocated optimally across a given area. This model considers both the location of facilities and their allocation to demand points, such as residents or service users. It seeks to maximize or minimize an objective function (e.g., reducing travel distance, maximizing coverage) under certain boundary conditions, which could include factors like budget, capacity, and service area constraints (The International Knowledge Centre for Engineering Sciences and Technology, 2021) The spatial optimization model can be applied to the school bus stop allocation problem in Ho Chi Minh City's inner districts, similar to other location-allocation challenges for public facilities. n this case, demand points represent students' residences or school locations, and supply points are the proposed bus stops. The problem can be divided into three main types: location problem, where the aim is to determine the optimal placement of bus stops; allocation problem, where the bus stops are fixed, and the goal is to assign students to those stops; and the location-allocation problem, where both the placement of bus stops and the assignment of students need to be optimized

2.3. Previous research

The School Bus Routing Problem (SBRP) addresses the optimization of school bus fleets to ensure efficient student transportation to and from school (Li, 2017).This optimization process must satisfy a set of critical constraints, including bus capacity, the number of buses available, school start times, and maximum travel times (Leiva, 2010); (Spasovic, 2001). Numerous studies indicate the difficulty in designing routes that adequately meet all of these requirements (see (Li, 2017) (Leiva, 2010). The extensive range of SBRP variables complicates achieving a balance between minimizing costs for the school system and maintaining equitable transportation standards for students (Spasovic, 2001). The bus stop selection sub-problem is addressed initially, as the location and demand associated with each bus stop serve as essential inputs for the subsequent bus routing problem. The bus stop selection sub-problem involves determining a suitable bus stop location for each student, typically chosen from a set of pre-approved candidate locations provided by the district. These candidate locations may be selected based on several criteria, including street-side features (e.g., road visibility that enhances safety), specific bus stop characteristics (e.g., available space for student waiting off-street), and characteristics of the student's route (e.g., proximity to their path from home to the bus stop). (Ellegood, Solomon, North, & Campbell, 2019)

The selection of optimal bus stops for school bus systems is a critical component of transportation planning, particularly in dense urban environments like Ho Chi Minh City (HCMC). Bus stop selection must balance multiple factors such as student demand, walking accessibility, safety, and urban infrastructure constraints. This review will focus specifically on bus stop selection as part of the school bus routing problem (SBRP), using Geographic Information Systems (GIS) and existing research on bus stop selection and identifies key themes and gaps, with an emphasis on its application to Ho Chi Minh City. The literature was categorized into the following sectors:

1. Bus stop selection criteria
2. Optimization of Bus Stop Selection
3. GIS in Bus Stop Allocation
4. Safety & Walking Accessibility

Table 1. Literature Review Summary (Personal Made)

Sector	Reference	Key findings
Bus stop selection criteria	(Hess, 2004)	Distance between bus stops, their proximity to sidewalks, walking distance, and other safety concerns
	(National Center for Safe Routes to School and the Pedestrian and Bicycle Information Center, 2010)	Lower traffic and speeds. Streets with sidewalks or safe pedestrian paths, Avoid railroad crossings;
	(Ibeas, 2010)	Distance between bus stops Time spent at stops and on the bus
Optimization of Bus Stop Selection	(Ellegood, Solomon, North, & Campbell, 2019)	Clustering students based on geographic proximity

	(Jingxuan Ren, 2019)	Clustering students into fewer Centralized stops
	(Michael Galdi, 2016).	Using the state guideline for minimum distance between bus stops
	(Baozhen Yao, 2016)	aggregation-based clustering algorithm to clustering stops
GIS in Bus Stop Allocation	(Andersen & Landex, 2009)	Using Catchment area, Service Area Approach
	(Michael Galdi, 2016).	Network Analyst, Closest facility
	(Junhyuk Park, 2010), (Alharbi, 2023) (Debnath, 2024)	Location Allocation
Safety & Walking Accessibility	(Michael Galdi, 2016).	400 meters from the user's residence to the bus stop
	(El-Geneidy, 2013).	Walking distance to transit is 400 meters or 5 minutes walk
	(Jiang, 2022)	people's preferred walking time for buses is between 5 to 10 minutes. Less than 10% of respondents said they would walk for 15 minutes to take the bus

Bus stop selection criteria

The data requirements for addressing the bus stop selection sub-problem encompass policy guidelines on acceptable bus stop locations, a list of potential stops, each student's residential address, assigned school, a distance matrix mapping walking routes from residences to candidate bus stops, and policies dictating maximum allowable walking distances for students. For instance, the study by (Hess, 2004) various "street-side factors" to optimize bus stop placement, including minimum stop separation, proximity to sidewalks, walking distance, and safety considerations. School bus systems often align with the (National Center for Safe Routes to School and the Pedestrian and Bicycle Information Center, 2010), Prioritize streets with lower traffic and speeds. Avoid multi-lane roads, opt for streets with sidewalks or safe pedestrian paths, and ensure enough space for walking if paths are unavailable. Minimize left turns and avoid stops that require backing up. Avoid railroad crossings; if unavoidable, ensure proper signage and crossing arm protection. Select stops with clear visibility for both pedestrians and drivers. As demonstrated in research by (Ibeas, 2010), which utilizes acceleration and deceleration data to adapt optimal spacing across a school system. These studies aim to ensure that no student needs to walk more than a specified distance to access a bus stop. As a results, there are some key criteria in selecting school bus:

- **Sidewalk Presence:** School bus stops must be situated within a 30-meter buffer from existing sidewalks.
- **Avoid Unsafe Roads:** Students are prohibited from walking along or crossing major roads that are classified as “unsafe.”
- **Student Walking Distance:** School bus stops must be assigned within a 500 walking distance along roadways from each student's residence

Optimization of Bus Stop Selection

The optimization of bus stop selection in SBRP focuses on reducing the number of stops while ensuring accessibility for students. (Ellegood, Solomon, North, & Campbell, 2019) reviewed contemporary trends in school bus routing, with a focus on stop minimization strategies that reduce travel time and improve route efficiency. Their work emphasizes the importance of clustering students based on geographic proximity, which allows for the minimization of bus stops without sacrificing accessibility. (Michael Galdi, 2016) employed a GIS-based heuristic approach in optimizing bus stop selection. Their work demonstrated that applying heuristic methods can lead to effective solutions by simplifying complex optimization problems. The study by (Leiva, 2010) demonstrated that maintaining an optimal frequency of bus stops for a bus service can lead to savings of over 10% on a single route. Additionally, fewer bus stops can enhance the concentration of students at those locations, which may lead to an increase in behavioral issues. Therefore, while it is essential to minimize costs by reducing the number of bus stops and shortening routes, it is equally important to maximize the overall student experience. Reducing the quantity of bus stops contributes to significant savings in fuel consumption and time spent stopping (Michael Galdi, 2016). It also reduces vehicle maintenance costs and eases traffic congestion, according to the (University of North Carolina Highway Safety Research Center, 2010). (Michael Galdi, 2016) emphasized the increasing importance of carefully choosing bus stop locations While fewer stops may mean longer walks for students, it ultimately reduces the overall time spent on the bus leading less total travel time (Avebury, Gower Publishing Company, 1990); (Michael Galdi, 2016)

GIS in Bus Stop Allocation

GIS provides a powerful tool for bus stop selection by enabling planners to visualize and analyze spatial relationships between students' homes, schools, and road networks. (Andersen & Landex, 2009) conducted a study on GIS-based approaches to public transit stop selection, focusing on the use of spatial analysis to determine the catchment areas for bus stops. Their work provides a foundation for using GIS in school bus stop selection by emphasizing the role of geographic clustering in optimizing stop locations. A catchment area is defined by geographical boundaries which indicates the geographical boundaries using Buffer analysis, with the buffer size defined by walking distance criteria. The Service Area Approach is suitable for broad investigations of mass transit, such as station positioning and travel potential analysis, given detailed datasets. This approach is ideal for improving station accessibility while overcome barriers like major roads or rivers. (Andersen & Landex, 2009). (Michael Galdi, 2016) used GIS to optimize school bus stops in Howard County, Maryland. (Debnath, 2024) uses ArcGIS for bus stop allocation aligns directly with public transit planning by addressing key challenges in urban mobility. It focuses on strategically placing bus stops near zones of high pedestrian activity, such as residential areas, schools, or commercial districts. This ensures accessibility for a majority of commuters while adhering to predefined walking distance thresholds, typically ranging from 400 to 500 meters. The location-allocation network dataset in ArcGIS enables planners to analyze potential candidate locations for bus stops. By employing methods Maximize Attendance, the tool identifies optimal bus stop locations that balance proximity to users and service coverage. In practice, this method helps transit authorities to minimize the total walking distance for users while maximizing the number of people served within a reasonable range.

Safety & Walking Accessibility

Walking accessibility is a critical criterion in bus stop selection, as stops should be located within a reasonable walking distance for students while ensuring their safety. (Jingxuan Ren, 2019) integrated walking accessibility into their algorithm, ensuring that bus stops were placed within a certain walking radius from student homes. Walking distance standards vary across cities, but the goal is to ensure that students do not have to walk excessively far in unsafe or congested areas. Safety considerations are paramount in urban environments, where high traffic volumes and inadequate pedestrian infrastructure can pose risks to students. (Michael Galdi, 2016) considered safety in their bus stop placement model, using GIS to analyze traffic patterns and identify safe, accessible locations for bus stops. (Baozhen Yao, 2016) also considered walking accessibility and safety when developing their two-stage algorithm, ensuring that bus stops were placed in locations that minimized walking distances while avoiding high-traffic or unsafe areas.

Several studies, such as (Ceder, 1983); (Ke, 2010) have utilized mathematical and GIS-based algorithms to minimize unnecessary bus stops, focusing on reducing the distance students need to walk. The most commonly cited standard for walking distance to transit is 400 meters (El-Geneidy, 2013).However, this is not a hard boundary, and people are willing to walk further to faster services (Walker, basics: walking distance to transit, 2013). A 2020 German survey found that people's preferred walking time for buses is between 5 to 10 minutes. Less than 10% of respondents said they would walk for 15 minutes to take the bus (Jiang, 2022)

In public transit contexts, planners typically aim for a 400-meter distance from residence to bus stop (Delmelle, 2012), equating to a five-minute walk—a standard considered both reasonable and conducive to optimal ridership. Key criteria include a minimum stop separation of 400 meters in roadway distance, bus stop presence within a 30-meter sidewalk buffer, avoidance of unsafe roads by ensuring stops are within a 15-meter buffer of roadways, and assigning stops within 400 meters (roadway distance) from each student's home. Other's literature provides insights into the outdoor walking speeds of apparently healthy adults. The walking distance vary around the world and depend on how far people will be willing to walk. This report is going to consider the walking distance is 500 meters.

Conclusion

The literature on school bus stop selection highlights key factors like safety, accessibility, and walking distance. Critical guidelines include placing bus stops within a 500-meter walking distance from students' homes, ensuring proximity to sidewalks, and avoiding unsafe roads. Studies also stress the importance of locating bus stops on streets with low traffic volumes, avoiding multi-lane roads, and ensuring adequate visibility for both pedestrians and drivers (Hess, 2004) (Ellegood, Solomon, North, & Campbell, 2019). Safety concerns further emphasize the need to avoid railroad crossings and ensure safe pedestrian paths. GIS tools are essential for analyzing spatial relationships and visualizing optimal stop locations, considering the geographical distribution of students and road networks (Andersen & Landex, 2009); (Debnath, 2024). Ultimately, the focus remains on minimizing the walking distance for students while prioritizing their safety and ease of access to bus stops.

3. Methodology

This study's methodology is designed to identify optimal locations for school bus stops in Ho Chi Minh City's inner districts, focusing on criteria for student safety, accessibility, and service efficiency. Data collection involved multiple datasets to ensure comprehensive coverage of relevant factors. Key sources include population data from the 2019 Vietnam Census, which provides demographic information at district and ward levels to estimate the number of High School-aged children in each area, street network data sourced from OpenStreetMap, which includes road types, sidewalks, and walkable pathways, and school location data for evaluating proximity to student residences.

The Research uses ArcGIS Pro 3.1.0 by Ersi Inc, focusing on Location-Allocation Analysis which is the primary tool used to select bus stop locations that maximize student accessibility. This step involves generating multiple candidate density across the study area and then configuring the model to allocate bus stops based on student density and proximity. The location-allocation process prioritizes locations that serve the highest concentration of students within the defined constraints. By focusing on these high-density areas, the model maximizes the number of students served while optimizing each bus stop's placement within a walkable distance which is 500 meters.

The quantiative survey (333 samples) and quantilative interviews (4 samples) are key in shaping the school bus stop allocation solution in Ho Chi Minh City's inner districts (Annex 1, Annex 2, Annex 3). Data from students, parents, teachers, and transportation professionals helps tailor the GIS's solution to meet community needs. The survey gathers insights on bus usage, walking distances, and safety concerns, while expert interviews highlight traffic conditions, coordination issues, and safety risks. Findings from both sources guide the allocation process by ensuring bus stops are within a 500-meter radius of student residences and prioritize high-density areas. Expert feedback helps refine stop placements for safety and coordination with public transport, and suggestions on improving safety measures and infrastructure are integrated to enhance the service. Combining these insights ensures a well-rounded strategy that maximizes coverage, minimizes walking distances, and improves safety and efficiency.

The final outcome is a visual map displaying the optimized bus stop locations, each with a delineated buffer area showing the student population coverage. This dual-layered approach—combining the strategic placement of location-allocation with the population-—ensures that the proposed bus stop network not only meets accessibility and safety standards but also maximally covers the target student population within the designated walking distance. This methodology provides a data-driven basis for decision-making, supporting efficient and equitable school bus stop planning in densely populated urban environments.

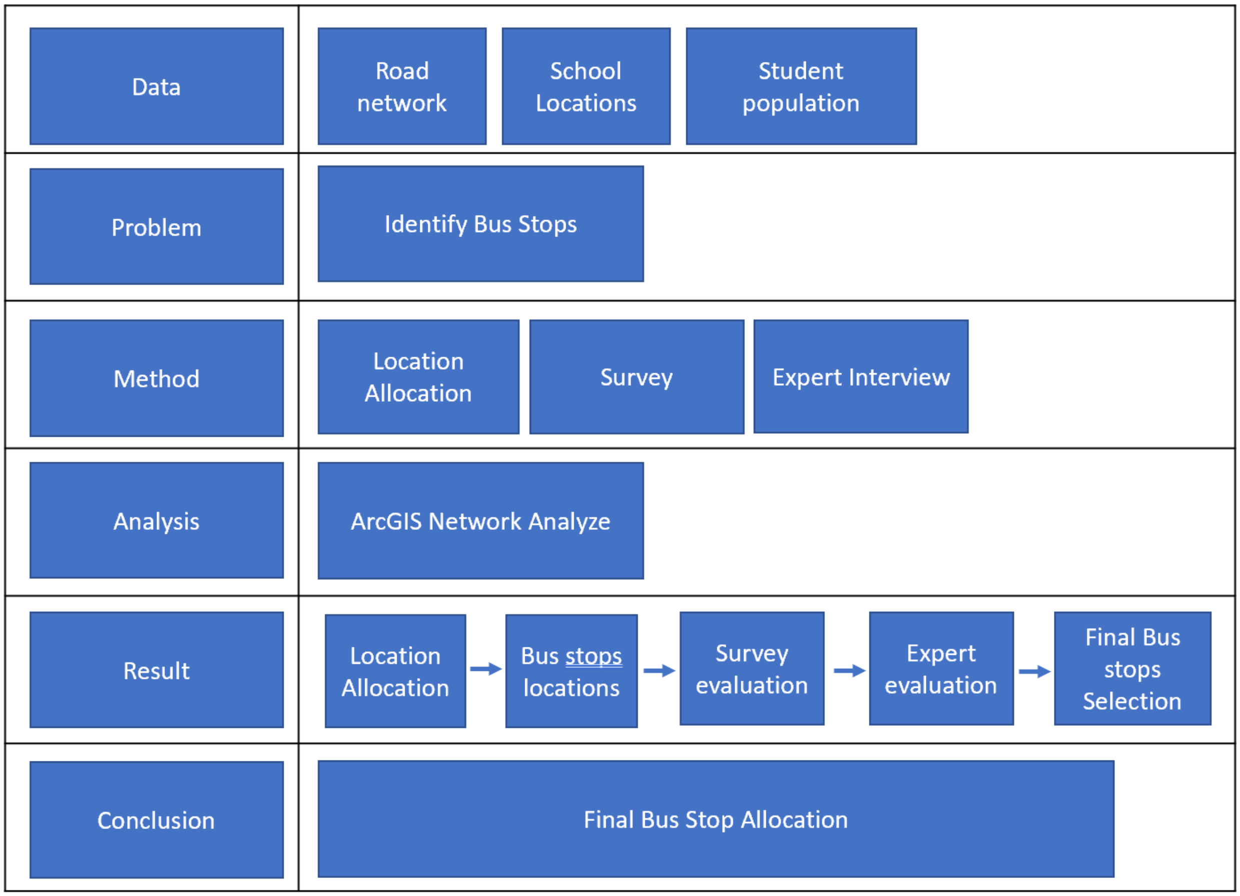


Figure 4. Research Methodology

4.Data Collection and Analysis

4.1. Data Collection

a. ArcGIS data

This study uses a GIS-based approach to identify and assess the spatial distribution of the 15–18-year-old student population in Districts 1 and 3 of Ho Chi Minh City. The data used in this study were collected and processed through a combination of secondary demographic and open access spatial datasets and integrated and visualized using

ArcGIS software. The resulting ward-level student density estimates were visualized using ArcGIS and are shown in Figure 5 .

To analyze accessibility and support bus stop planning, the study obtained road network data from OpenStreetMap (OSM). This dataset includes detailed information on streets, intersections, and transportation infrastructure in Districts 1 and 3. The data was downloaded, cleaned, and spatially referenced in ArcGIS for use in network analysis. The road network layer provides the basis for generating service areas. The collected demographic and road network data were integrated into ArcGIS for spatial analysis and visualization. The workflow includes:

- Geocoding ward boundaries using official administrative shapefiles
- Joining attribute tables (population data) to spatial ward layers
- Estimating student density at the ward level
- Overlaying student density data with road networks to support accessibility and service area analysis for proposed school bus stops

All maps and spatial outputs are personally developed by the researcher using ArcGIS tools such as Choropleth Mapping, Attribute Join, and Network Analyst.

b. Quantitative Data

This study used convenience sampling method to collect data from high school students in Districts 1 and 3 of Ho Chi Minh City. The sample was selected based on accessibility and ease of contacting potential participants, including students and their parents who participated in or expressed interest in using school bus services.

The questionnaires were distributed to students and parents via email and online learning platforms. After data collection, incomplete or invalid responses (e.g., missing information or inadequate responses) were excluded from the data set. After screening, a total of 333 valid responses were retained for analysis.

SPSS (Statistical Package for Social Sciences) was used to process and analyze the collected data. Through data analysis, the distribution of school bus stops and the key factors affecting students' school bus travel needs are obtained.

c. Qualitative Data

Qualitative research uses in-depth expert interviews as the main method of data collection. A total of five interviews were conducted, each lasting between 30 and 45 minutes. Participants were selected based on their expertise and included transportation experts, school administrators, and urban planners, all of whom had direct experience related to school transportation systems and urban planning.

Each interview was conducted in a one-to-one manner using a semi-structured format. With the consent of the participants, the interviews were audio-recorded and then transcribed for study analysis. Prior to the discussion, the researcher provided respondents with an overview of the research background, including the results of the GIS-based location allocation model, via a video or presentation slides. This ensured that participants had a clear understanding of the research context.

The interview content is mainly divided into five parts. The first section collected basic information about the respondents, such as their organization, years of work experience, and areas of expertise. The second section explores their assessment of the current transportation situation in their school zones, including the percentage of students using school buses and the difficulties faced in using school buses. The third section focuses on identifying the main challenges of setting up school bus stops, addressing safety issues, and examining how school buses can be integrated with the wider public transportation system. In the fourth part, participants were asked to think about the criteria for selecting a school bus stop and the importance of walking distance. The final section invited them to come up with solutions to improve the prepared bus stop allocations.

The collected data were coded and analyzed using Atlas.ti, a qualitative research software developed by the Technical University of Berlin. This analytical approach identifies recurring themes, expert insights, and patterns relevant to improving school bus allocation programs.

4.2. ArcGIS Location Allocation Analysis

In order to effectively allocate school bus stops according to the distribution of students in District 1 and District 3 of Ho Chi Minh City, a series of spatial analysis procedures of ArcGIS were used in the study. First, a student density surface was generated by applying kriging interpolation to the district-level student population data. This approach allows the creation of a continuous density map that highlights areas with a high concentration of students aged 15-18 years. The study created a contour map with gradient color symbols (from light to dark) to visually distinguish between low-density and high-density areas to help prioritize areas that need school bus service.

Subsequently, road network data of the study area were imported from OpenStreetMap and refined in ArcGIS. Using the Intersect tool, you can identify key intersections between primary and secondary roads as potential school bus stop locations. A web dataset was then created to simulate walking routes and configure specific travel modes to represent student movements, typically walking distance to a bus stop.

The location-allocation tool in ArcGIS Network Analyst is then used to determine the optimal bus stop locations. The purpose of this analysis is to maximize coverage of students within a defined service radius (e.g., 500 meters). Candidate facilities are defined using the intersections identified previously, while demand points come from either ward centroids or student density values of interpolated raster cells.

The final output includes a visual network of selected school bus stops. Finally, demand points are imported and mapped to verify accessibility. The 5-minute walk threshold (or equivalently a 500-meter buffer) is used to ensure that students in high-density areas can actually reach nearby stations. This spatial validation ensures that the proposed site location matches the actual needs of students and urban accessibility.

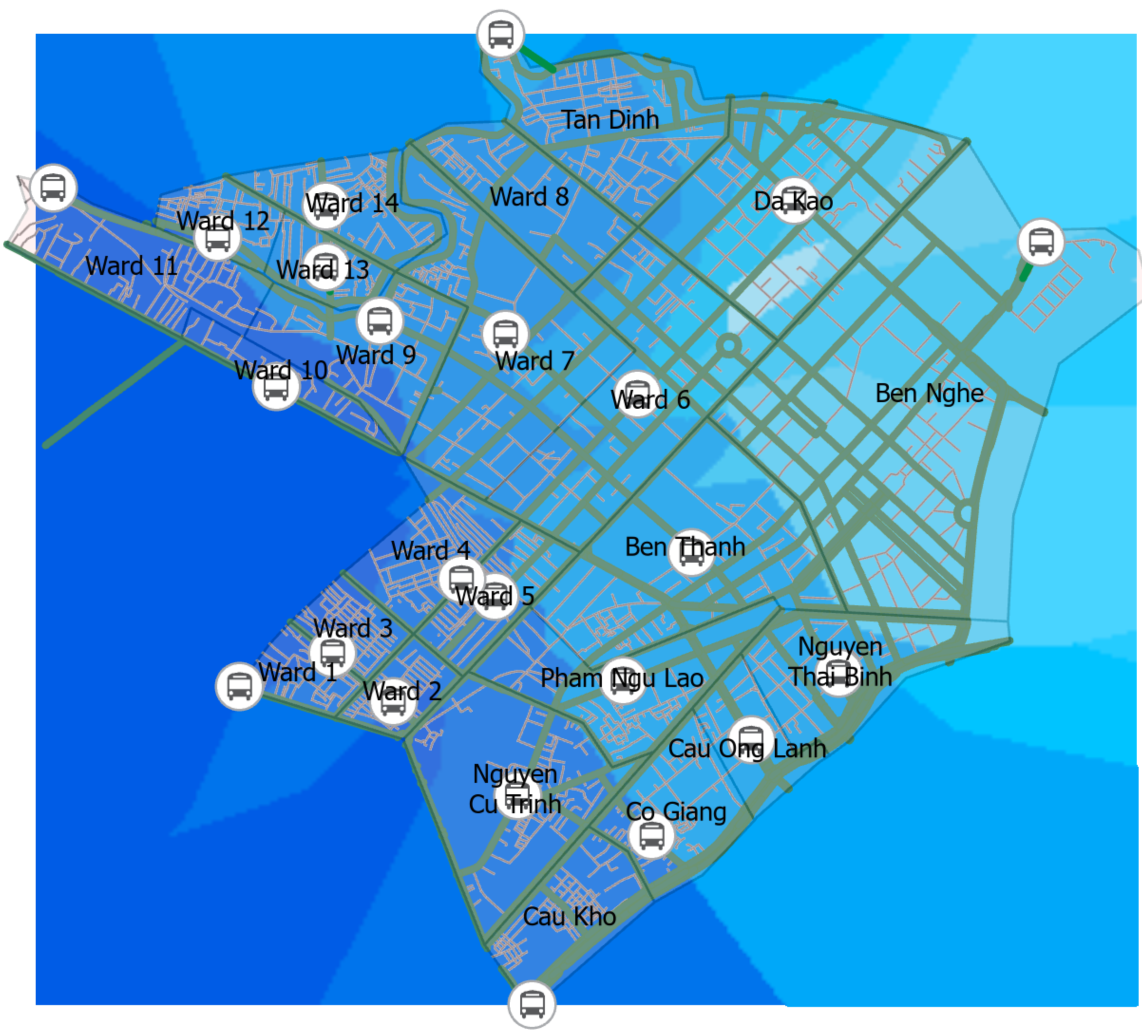


Figure 5. School bus stop allocation for High School Student of District 1 & 3's wards (personal made by Arc GIS)

4.3. Quantitative Analysis

The sample consisted of 69.7% male respondents (n = 232) and 30.3% female respondents (n = 101), indicating a higher representation of male participants in the survey.

In terms of age, the majority of respondents (58.3%, n = 194) were between 15 and 18 years old, followed by 38.7% (n = 129) who were above 18 years old, and a small portion (3.0%, n = 10) who were under 15 years old. This age distribution suggests that the survey primarily captured input from students in the target high school age range.

Regarding occupation, 61.6% (n = 205) of respondents identified as students, 30.6% (n = 102) as parents, and 6.3% (n = 21) as teachers or school administrators. A minimal number (1.5%, n = 5) indicated other occupations. This occupational breakdown ensures a balanced perspective, capturing views from both direct users of the school bus system (students) and key decision-makers or stakeholders (parents and educators).

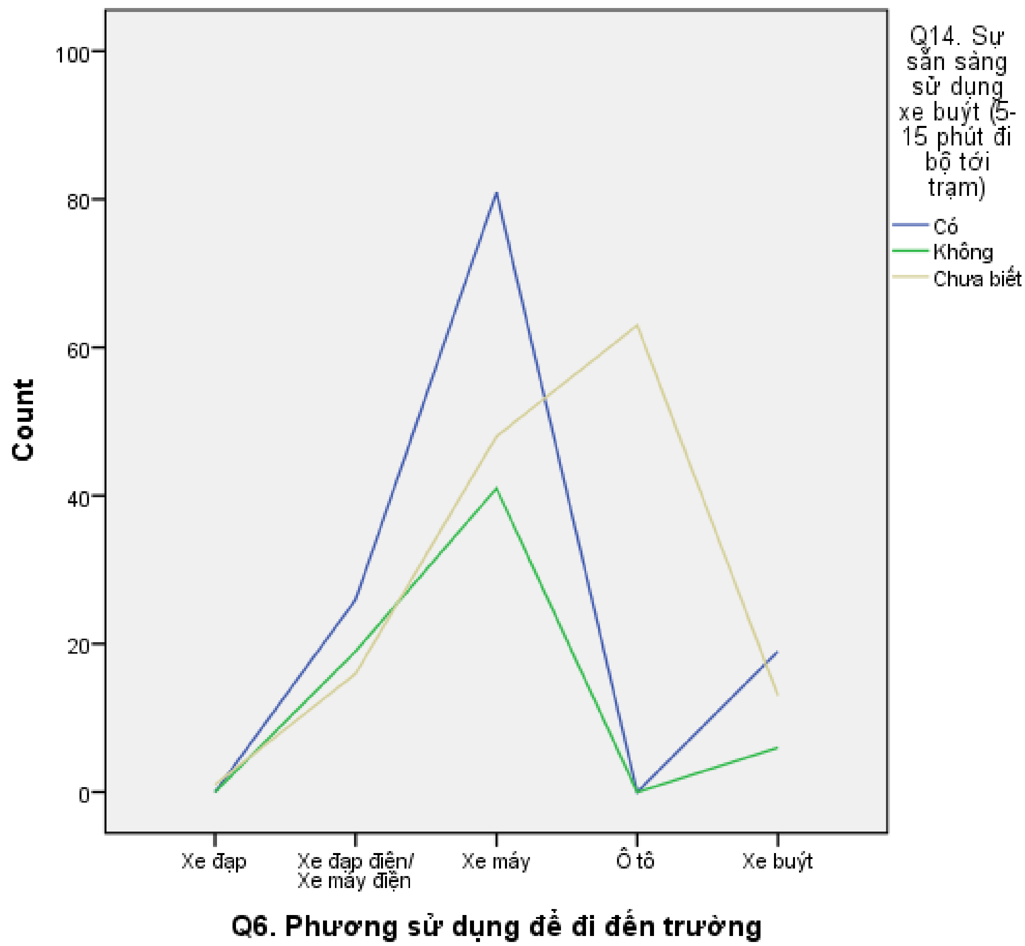


Figure 6. Relation between students' current modes and their willingness to switch to school bus services of High School Student of District 1 & 3's wards (personal made)

The chart illustrates how students' current modes of transportation influence their willingness to switch to school bus services. Students who currently commute by motorbikes or electric bicycles tend to show a higher level of willingness to use school buses compared to those who travel by car. This suggests that students who currently use motorbikes or electric bicycles represent the most promising target group for the development of school bus services.

Tests of Between-Subjects Effects

Dependent Variable: Q14. Sự sẵn sàng sử dụng xe buýt (5-15 phút đi bộ tới trạm)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	72.908[a]	11	6.628	11.000	.000
Intercept	137.310	1	137.310	227.885	.000
Q2.Tuổi	.074	2	.037	.061	.940
Q6. Phươngtiệnchínhthường đượcsửdụngđểđiđến	21.836	4	5.459	9.060	.000
Q2.Tuổi * Q6. Phươngtiệnchínhthường đượcsửdụngđểđiđến	.566	5	.113	.188	.967
Error	193.416	321	.603		
Total	1659.000	333			
Corrected Total	266.324	332			

a. R Squared = .274 (Adjusted R Squared = .249)

Figure 7. Tests of Between-Subjects Effects for Willingness to Use the Bus (5–15 Minutes Walking Distance) with Age and Current Mode (Self-made)

Student age does not have a statistically significant effect on the willingness to use school buses (Sig. = 0.940 > 0.05). In contrast, the current mode of transportation has a highly significant impact on students' willingness to use school buses (Sig. = 0.000 < 0.05). This indicates that students using different types of transportation (e.g., motorbikes, cars, bicycles) exhibit varying levels of willingness to switch to school bus services. Furthermore, the interaction between age and mode of transportation is not statistically significant (Sig. = 0.957 > 0.05), suggesting that the combined effect of these two variables does not influence the decision to use school buses.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Q19. Sử dụng nếu tiết kiệm thời gian	333	1.0	5.0	3.796	1.1849
Q19. Sử dụng nếu tiết kiệm chi phí so với phương tiện cá nhân	333	1.0	5.0	3.895	1.1372
Q19. Sử dụng nếu được nhà trường khuyến khích sử dụng	333	1.0	5.0	3.814	1.1622
Q19. Sử dụng nếu trạm xe buýt gần nhà và dễ tiếp cận	333	1.0	5.0	3.805	1.1411
Q19. Sử dụng để tăng sự thuận tiện trong di chuyển hằng ngày	333	1.0	5.0	3.754	1.1870
Valid N (listwise)	333				

Figure 8. Descriptive Statistics of Factors Influencing Bus Usage Intention (Self-made)

The survey results indicate general agreement with the factors affecting trust in health when using school buses. The most agreed-upon factor was "Using the bus if it saves costs compared to personal transportation" (Mean = 3.895), while the least agreed-upon factor was "Using the bus to increase convenience in daily commuting" (Mean = 3.754). The standard deviation suggests a moderate level of opinion dispersion, indicating a relatively high level of consensus in the evaluations.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Q22. Khoảng cách từ nhà đến trạm xe buýt lý tưởng sử dụng xe buýt: Trên 2000m (trên 20 phút đi bộ từ nhà đến trạm xe buýt)	333	1.0	5.0	2.826	.8358
Q22. Khoảng cách từ nhà đến trạm xe buýt lý tưởng sử dụng xe buýt: 1500m đến 2000m (15-20 phút đi bộ từ nhà đến trạm xe buýt)	333	1.0	5.0	2.826	.8175
Q22. Khoảng cách từ nhà đến trạm xe buýt lý tưởng sử dụng xe buýt: 1000 đến 1500m (10-15 phút đi bộ từ nhà đến trạm xe buýt)	333	1.0	5.0	3.844	1.0697
Q22. Khoảng cách từ nhà đến trạm xe buýt lý tưởng sử dụng xe buýt: 500m đến 1000m (5-10 phút đi bộ từ nhà đến trạm xe buýt)	333	1.0	5.0	4.015	.8865
Q22. Khoảng cách từ nhà đến trạm xe buýt lý tưởng sử dụng xe buýt: Dưới 500m (dưới 5 phút đi bộ từ nhà đến trạm xe buýt) T	333	1.0	5.0	4.045	.9123
Valid N (listwise)	333				

Figure 9. Descriptive Statistics of Ideal Walking Distances from Home to Bus Stops to Encourage Usage (Self-made)

The survey results show general agreement on ideal walking distances to bus stops. The most preferred option was bus stops located within 500 meters from home (Mean = 4.045), followed closely by 500–1000 meters (Mean = 4.015). The least preferred options were distances over 1500 meters, including 1500–2000m and over 2000m (Mean

= 2.826 for both). Standard deviations indicate a moderate level of consensus among participants.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Q24. Ý kiến về các giải pháp đang nghiên cứu: Các trạm xe buýt phải có nằm khoảng cách có thể đi bộ được	333	1.0	5.0	3.799	1.1765
Q24. Ý kiến về các giải pháp đang nghiên cứu: Các trạm xe buýt phải bố trí tại đường có vỉa hè, dễ dàng cho học sinh đi bộ	333	1.0	5.0	3.892	1.1487
Q24. Ý kiến về các giải pháp đang nghiên cứu: Các trạm xe buýt phải bố trí tại các điểm đông dân cư, học sinh	333	1.0	5.0	3.814	1.1622
Q24. Ý kiến về các giải pháp đang nghiên cứu: Các trạm xe buýt phải bố trí tại các điểm không cấm xe buýt lưu thông	333	1.0	5.0	3.811	1.1421
Q24. Ý kiến về các giải pháp đang nghiên cứu: Các trạm xe buýt phải bố trí gần các trạm xe buýt công cộng, các trạm Metro	333	1.0	5.0	3.763	1.1800
Valid N (listwise)	333				

Figure 10. Descriptive Statistics on Agreement with Proposed Bus Stop Placement Solutions (Self-made)

The survey results show general agreement with the proposed solutions for school bus stop allocation. The most agreed-upon solution was placing bus stops on streets with sidewalks for easy student access (Mean = 3.892). The least agreed-upon solution was locating bus stops near public bus and Metro stations (Mean = 3.763). The standard deviation indicates a relatively high level of consensus among participants.

Key findings indicate that students who currently commute by motorbikes or electric bicycles are the most open to switching to school buses, making them a prime target group for service development. In contrast, student age and the interaction between age and transport mode have no significant effect on willingness to use school buses, reinforcing that current mode of transport is the most influential factor.

There is strong agreement on factors influencing trust and preference, such as, ideal walking distances to bus stops (with closer stops being significantly preferred), and practical placement of bus stops (e.g., on streets with sidewalks).

Overall, the results highlight the importance of:

- Targeting users of motorbikes/e-bikes to boost adoption,
- Locating bus stops within 500 meters of homes,
- Safely placing on street with sidewalks

4.4. Qualitative Analysis

There are four main thematic areas: current bus stop issues, bus stop selection, covered criteria in current bus stop planning approach, and proposed improvement suggestions.

Experts collectively pointed out several critical issues affecting current bus stops, emphasizing both infrastructure and operational deficiencies. They highlighted the absence of a dedicated transit system for students, shelter at stops, poor distribution of bus stop locations, and frequent sidewalk encroachment by motorbike taxis. Additionally, concerns were raised about the lack of coordinated planning and unsafe design features. A recurring theme across all observations was the heightened safety risk caused by poor design, insufficient lighting, and unsuitable placement.

“Some alleys are too narrow, children can’t walk safely, and people are not used to walking.” (Expert 3)

In the theme of bus stop selection, experts consistently emphasized the importance of strategic placement that enhances both accessibility and safety. Suggestions included positioning the school as the final stop, prioritizing safety as the foremost criterion, and ensuring minimal traffic disruption. These perspectives reflect a shared understanding that bus stop placement must be user-centered and tailored to the specific context to effectively meet student needs.
“We consider accessibility, service radius, and walking distance, all equally important.” (Expert 1)

In the theme of criteria covered, several common elements intergrated in current bus stop planning approaches. Experts noted that distance and population density are already taken into account, along with a focus on safety and service coverage. Additionally, considerations such as user needs, student locations, and overall accessibility were highlighted. These insights indicate a shared recognition of foundational criteria, though they also suggest opportunities for refinement and greater integration.
“We considered accessibility—how easy it is for the student to get there” (Expert 2)

In the theme of proposed improvement suggestions, experts offered a range of actionable recommendations aimed at enhancing the school bus system. Suggestions included placing stops near crossings and developing residential models close to parks, creating designated waiting areas for parents, and adapting bus stops to align with the growth of social infrastructure. Additional recommendations involved incorporating parental input into stop design, promoting green transportation policies, and ensuring legal support. Collectively, these proposals reflect a cohesive approach that integrates infrastructural, policy, and behavioral interventions to strengthen school bus usage and overall system effectiveness.

“Government support, operational subsidies, and legal regulations for schools are key to encouraging school bus zones.” (Expert 4)

Figure 11. Expert Interview Responses Word Cloud (Self-made)

This word cloud provides a visual representation of the most frequently discussed concepts related to school bus planning and transportation challenges, based on qualitative data from expert interviews and supporting research.

The most dominant term, "safety", indicates it is the primary concern across all discussions, highlighting its central role in the planning and design of school bus systems. Closely associated concepts like "accessibility", "distance", and "congestion" further reinforce the importance of placing bus stops within a convenient walking range and ensuring safe, efficient routes. The prominence of "distance" and "travel" suggests that proximity to bus stops and commute time are significant factors influencing user adoption and satisfaction.

Terms such as "lack", "shelter", "sidewalk", and "lighting" point to specific infrastructure condition frequently identified as contributing to unsafe or inaccessible conditions. The presence of "climate", "coverage", and "regulation" also reflects broader concerns about environmental comfort, service distribution, and the need for policy support in improving school transportation systems.

Additionally, terms like "traffic" and "congestion", emphasize the operational and spatial challenges that affect both school access and transport flow. The inclusion of words such as "education", "connectivity", and "parent" also highlights the human-centered dimensions of the system, pointing to the importance of stakeholder collaboration.

		2: E1 20	3: E2 11	4: E3 12	5: E4 17	Totals
Bus Stop Selection Criteria	14	5	2	1	6	14
Covered	8	2	1	2	3	8
Current School Bus Issues	21	5	5	6	5	21
Proposal Improvement Suggestion	14	6	3	3	2	14
Totals		18	11	12	16	57

Figure 12. Code-document Analysis (Self-made)

The analysis shows that while some selection criteria—like distance and accessibility—are already considered in current planning (as reflected in the "Covered" code and expert responses), this coverage remains limited. Key elements such as climate conditions, safety features, and parent input are still underrepresented in implementation. The low coding frequency under "Covered" (8) highlights this gap, suggesting that many critical factors remain insufficiently addressed. The word cloud further supports this interpretation, with prominent terms such as “safety,” “accessibility,” “regulation,” “climate,” and “planning”—emphasizing that forward-looking, integrative strategies are not only widely discussed but central to the recommendations for an improved and more effective school transportation system.

5.Results and Discussion

The optimization of school bus stop locations was guided by a combination of quantitative survey data and qualitative expert opinion, ensuring that the final recommendations were both evidence-based and practical. The survey collected perspectives from high school students, parents and educators and highlighted key priorities for school bus users. Students who currently commute by motorcycle or electric bike are most likely to switch to school buses, proving they are the primary target group. Respondents highlighted three key safety-related factors: having sidewalks for safe boarding and alighting, avoiding dangerous roads, and ensuring easy access to transportation, preferably within a 500-meter walking distance from home. These insights were echoed in the expert interviews, which also highlighted safety, accessibility and route planning as essential criteria.

Therefore, the final proposal incorporates these safety issues directly into the site selection process. Most of the changes apply to bus stop locations deemed unsafe or inaccessible, including near streets without sidewalks, bridges or major roads that are not pedestrian-friendly. These sites were either relocated or redesigned to improve safety and walkability in line with stakeholder expectations and expert planning standards.

To further support the uptake of school bus services – particularly for pupils who currently use scooters or e-bikes – it is recommended that schools and local authorities introduce supportive policies and regulations. These measures should aim to encourage people to switch to safer and more sustainable commuting modes through publicity campaigns, service trials and infrastructure improvements. At the same time, local regulations could consider restricting motorcycle use by students in high-risk areas while prioritizing safe, convenient routes for school buses.

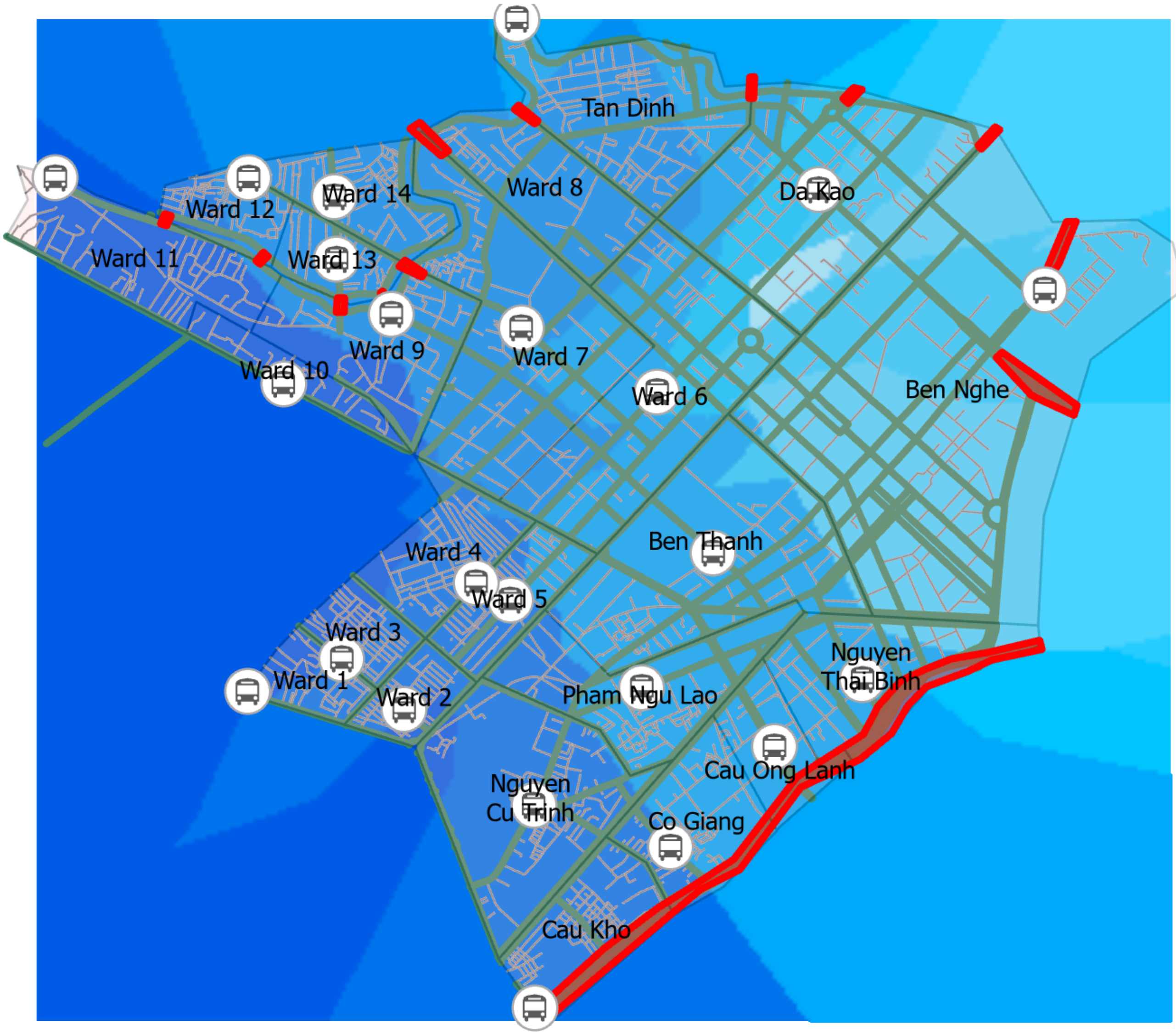


Figure 13. Optimization School Bus Stop locations after Quantitative and Qualitative Research

6. Conclusion and discussion

6.1. Conclusion

This study combined spatial analysis using ArcGIS with quantitative and qualitative data to identify optimal school bus stop locations and assess factors that influence students' willingness to use school bus services in Districts 1 and 3 of Ho Chi Minh City. This study demonstrated a GIS-based approach to mapping student distribution and accessibility, leading to evidence-based planning of bus stop allocations.

The findings also show that students who currently use motorcycles or electric bicycles are more willing to switch to school bus services, making them the main target group.. The preferred location for bus stops is on roads with pedestrian paths to facilitate safe and convenient travel for students, while bus stops close to public transportation hubs are less popular.

The ArcGIS location-allocation tool has proven effective in determining optimal bus stop within a 500-meter radius of student populations, ensuring that most areas with high student density are within a 5-minute walking distance. This spatial solution is consistent with the findings of the quantitative survey, which highlighted accessibility, perceived health, and cost-effectiveness as key drivers for the adoption of this solution.

6.2. Discussion

Recommendations:

To improve the efficiency and uptake of school bus services, future planning efforts should prioritize the accessibility and safety of bus stop locations. Stops should be located on streets with access roads and pedestrian infrastructure to ensure safe boarding and alighting of passengers. Keeping walking distances as short as possible (ideally within 500 metres of a student’s home) will also increase accessibility and encourage more students to participate. Special attention should be paid to students who currently commute by motorcycle or electric bicycle, as this group demonstrates the highest willingness to switch to school buses. Additional recommendations from experts could also be considered in the future, such as using the school as the final bus stop or providing shelters at bus stops that are suitable for Vietnam's climate

Furthermore, the integration of GIS-based planning tools, such as ArcGIS Network Analyst, into transportation policy is highly recommended. These tools support continuous monitoring and enable spatial decision making by integrating real-time data on student distribution and infrastructure changes, keeping school transportation systems adaptive and efficient.

Finally, successful implementation requires close collaboration between schools and local authorities. Close coordination with educational institutions and city transportation agencies will help ensure that proposed bus stops are consistent with school timetables, student needs, and city development regulations, creating a more coherent and responsive transportation network.

Limitation

This study proposes a practical reccommendation for optimizing school bus stop locations; however, several limitations should be noted. A key limitation is the lack of precise student location data, which limits the ability to fully customize site locations based on actual demand patterns. Instead, general residential areas are used, which may not accurately reflect the distribution of students. Furthermore, this analysis does not incorporate detailed origin-destination routes, limiting the accuracy of route optimization and travel time estimates.

The study also relies on a static and partially outdated dataset that may not capture recent changes in population, school enrollment or traffic conditions. Furthermore, the limited availability of demographic data necessitated the use of proportionality assumptions to estimate the distribution of students across constituencies. Future research should prioritize improving the collection of student demographics at the ward level for more accurate planning.

Despite these limitations, the integrated approach presented in this paper provides a replicable model for optimizing school bus systems in other urban areas in Vietnam, contributing to the establishment of safer, more efficient, and sustainable student transportation networks.

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Annex

ANNEX 1: EXPERT INTERVIEW QUESTIONAIRE

Each interview lasts approximately 30-45 minutes. The research topic and methodology will be presented before asking questions. All responses will be recorded, and names will be encoded for research purposes.

Part 1: Respondent Information

1. What is the organization you are currently working for?
2. What is your current position?
3. What is your field or area of expertise?
4. How long have you been working in this field?

Part 2: Assessment of Traffic Conditions

5. How would you evaluate the current traffic conditions around schools?
6. In your opinion, what percentage of students currently use school buses?
7. What factors do you believe have the greatest influence on students and parents deciding to use school buses?

(For example: safety, cost, time)

→ Can you provide real-life examples of how these factors influence the decisions of students and parents?

8. Do you notice any differences in traffic conditions when there are or are not school bus stops?

Part 3: Challenges

9. Can you identify the main challenges in the current placement of school bus stops?

→ Can you share specific examples of bus stops facing these challenges?

10. What do you believe are the main causes of dangerous conditions around school bus stops?

11. Do you observe any inconsistencies between the school bus stop system and the public bus system? If yes, what are they?

→ How do these inconsistencies affect students' use of the services?

12. Do you notice any safety issues at school bus stops?

→ Are these safety issues frequent, and how severe are they?

The interviewer will present the results of school bus stop locations for experts to evaluate and assess. The bus stops are placed based on student density and the road system analysis method called Location Allocation. This method uses measurement scales to select school bus stop locations that can cover the maximum number of students' residences within a 500m radius.

Part 4: Survey

13. In your opinion, what criteria should be prioritized when selecting school bus stop locations?

14. Do you think areas with higher or lower student population density will have more school bus stops?

15. How do factors such as the distance from home to the bus stop and travel time affect students' decisions to use school buses?

→ Which of these factors do you think is more important, and why?

16. What criteria do you think the current bus stop placement approach has considered?

17. What criteria do you think the current bus stop placement approach has not considered?

→ Are there specific locations that need to be changed?

Part 5: Proposed Solutions

18. What suggestions do you have for improving the placement of school bus stops?

19. Have you implemented any measures to enhance the usage of school buses?

20. In your opinion, how can safety and accessibility at school bus stops be improved?
21. Do you believe it is necessary to revise policies or regulations related to the placement of school bus stops? If yes, what are your recommendations?

BẢNG HỎI PHỎNG VẤN CHUYÊN GIA

1 người khoảng từ 30-45 phút, chủ đề và phương pháp trong nghiên cứu sẽ được trình bày trước khi đặt câu hỏi. Các câu hỏi sẽ được ghi âm, mã hóa tên gọi để thuận tiện trong việc nghiên cứu

Phần 1: Thông tin người trả lời khảo sát

1. Đơn vị công tác của anh/chị là gì?
2. Chức vụ hiện tại của anh/chị là gì?
3. Lĩnh vực hoặc chuyên môn của anh/chị là gì?
4. Anh/chị đã làm việc trong lĩnh vực này được bao lâu?

Phần 2: Đánh giá thực trạng giao thông

5. Anh/chị đánh giá tình hình giao thông quanh các trường học hiện nay như thế nào?
6. Theo anh/chị, tỉ lệ học sinh sử dụng xe buýt trường học hiện tại là bao nhiêu phần trăm?
7. Những yếu tố nào anh/chị cho là ảnh hưởng lớn nhất đến quyết định sử dụng xe buýt trường học của học sinh và phụ huynh? (Ví dụ: an toàn, chi phí, thời gian)

→ Anh/chị có thể nêu ví dụ thực tế về cách mà các yếu tố này ảnh hưởng đến quyết định của học sinh và phụ huynh không?

8. Anh/chị có nhận thấy sự khác biệt nào về tình hình giao thông khi có hoặc không có trạm xe buýt trường học không?

Phần 3: Bất cập

9. Anh/chị có thể nêu ra những bất cập chính trong việc bố trí trạm xe buýt trường học hiện nay?
10. Anh/chị có thể chia sẻ ví dụ cụ thể về một trạm xe buýt gặp phải bất cập không?
11. Theo anh/chị, nguyên nhân chính gây ra tình trạng nguy hiểm xung quanh các trạm xe buýt là gì?
12. Anh/chị có nhận thấy sự không đồng bộ trong hệ thống trạm xe buýt trường học và xe buýt công cộng không không? Nếu có, đó là những điểm nào?

→ Sự không đồng bộ này ảnh hưởng như thế nào đến việc sử dụng dịch vụ của học sinh?

13. Anh/chị có nhận thấy bất kỳ vấn đề an toàn nào tại các trạm xe buýt trường học không?

→ Những vấn đề an toàn này có thường xuyên xảy ra không và mức độ nghiêm trọng của chúng như thế nào?

Người phỏng vấn sẽ trình chiếu kết quả của các vị trí trạm xe buýt trường học để các chuyên gia nhân định và đánh giá.

Các trạm xe buýt sẽ được bố trí dựa theo Mật độ học sinh và phương pháp phân tích hệ thống đường Location Allocation. Phương pháp này sẽ dung các thang đo để chọn ra vị trí trạm xe buýt trường học có thể phủ tối đa các vị trí ở của học sinh nằm trong phạm vi bán kính 500m

Phần 4: Khảo sát

13. Theo anh/chị, các tiêu chí nào nên được ưu tiên khi lựa chọn vị trí trạm xe buýt trường học?

14. Theo anh/chị, các phường có mật độ dân số học sinh cao hay thấp sẽ có nhiều trạm xe buýt trường học hơn?

15. Theo anh/chị, các yếu tố như khoảng cách từ nhà đến trạm, và thời gian di chuyển ảnh hưởng như thế nào đến quyết định sử dụng xe buýt của học sinh?

→ Yếu tố nào trong hai yếu tố này anh/chị cho là quan trọng hơn và tại sao?

16. Theo anh/chị, phương án bố trí trạm xe buýt hiện tại đã cân nhắc các tiêu chí nào?

17. Theo anh/chị, phương án bố trí trạm xe buýt hiện tại chưa cân nhắc các tiêu chí nào

→ Có các vị trí nào cần phải thay đổi không?

Phần 5: Đề xuất giải pháp

18. Anh/chị có đề xuất gì để cải thiện vị trí của các trạm xe buýt trường học hiện nay?

19. Anh/chị có sử dụng các biện pháp nào để tăng cường khả năng sử dụng xe buýt trường học không?
20. Theo anh/chị, làm thế nào để tăng cường an toàn và khả năng tiếp cận tại các trạm xe buýt trường học?
21. Anh/chị có nhận thấy cần thiết phải cải tiến chính sách hoặc quy định liên quan đến việc bố trí trạm xe buýt trường học không? Nếu có, anh/chị đề xuất gì?

ANNEX 2: SURVEY QUESTIONNAIRE ON SCHOOL BUS USAGE IN THE INNER DISTRICTS OF HO CHI MINH CITY

Interviewee:____________Interview Location:__________Form Code:_______

Dear Sir/Madam/Friend,

My name is Trần Thanh Đại Phúc, and I am a master's student in the Smart and Creative Urban Management program at the University of Economics Ho Chi Minh City (Vietnam) and the Transportation Science program at Hasselt University (Belgium). I am currently conducting research on the distribution of school bus stops in the inner districts of Ho Chi Minh City based on the needs of High School students using GIS (Geographic Information System) software.

School buses help reduce traffic congestion by replacing 30-50 personal vehicles and are the safest transportation option for children. Additionally, switching from diesel to electric buses saves costs and improves health and air quality.

I would greatly appreciate it if you could take a moment to complete this survey. I assure you that all information will be kept confidential and used solely for research purposes.

For any feedback or questions, please contact me via email: phuctran.622202211380@st.ueh.edu.vn.

Thank you sincerely for taking the time to answer this survey.

SECTION 1. GENERAL INFORMATION

Q1. Gender 1. Male 2. Female	
Q2. Age: 1. Under 10 years old 2. From 10 to 14 years old 3. From 14 to 18 years old 4. Over 18 years old	
Q3. Occupation: 1. Teacher/School Administrator 2. Student 3. Parent 4. Other	
Q4. School The school may be where you work, study, or where your child attends.	
District 3 1. Australian International School 2. Huỳnh Thúc Kháng Private School 3. Hồng Hà Private School 4. Thăng Long High School 5. Phan Sào Nam High School 6. Lương Thế Vinh High School 7. Lê Quý Đôn High School 8. Lê Lợi High School 9. Kiến Thiết High School 10. Hai Bà Trưng High School	District 1 15. Asia International School 16. Education Training School 17. Vietnam-Australia School 18. Võ Trường Toản High School 19. Văn Lang High School 20. Trần Văn Ơn High School 21. Nguyễn Du High School 22. Minh Đức High School 23. Huỳnh Khương Ninh High School 24. Đức Trí High School

11. Đoàn Thị Điểm High School 12. Colette High School 13. Bàn Cờ High School 14. Bạch Đằng High School	25. Đồng Khởi High School 26. Chu Văn An High School
Q5. Home location Home location is surveyed to guide the placement of bus stops to serve students as effectively as possible. Street: _______________Ward: __________________District: ______________	

SECTION 2. EXPERIENCE WITH TRANSPORTATION MODES

Q6. What is the main mode of transportation you usually use to get to school? 1. Walking 2. Bicycle 3. Electric bicycle 4. Motorbike 5. Car 6. Bus
Q7. How convenient is the main mode of transportation you use to get to school? 1. Very inconvenient 2. Inconvenient 3. Neutral 4. Convenient 5. Very convenient
Q8. Do you face any difficulties using public transportation or allowing your child to use public transportation? 1. Never 2. Rarely

3. Occasionally 4. Frequently 5. Always
Q9. What is the average travel time from your home to school using your main mode of transportation? 1. Less than 15 minutes 2. 15-30 minutes 3. 30-45 minutes 4. 45-60 minutes 5. Over 60 minutes
Q10. How often do you experience traffic congestion? 1. Never 2. Rarely 3. Occasionally 4. Frequently 5. Always

ECTION 3. BEHAVIOR IN USING SCHOOL BUSES

Usage Frequency	**Q11. How many times per week do you use school buses?** 1. 0 times 2. 1-2 times 3. 3-4 times 4. 5 or more times
	Q12. How long have you been using school buses? 1. Never 2. Less than 1 month 3. 1-6 months

	4. 6 months - 1 year 5. Over 1 year
Convenience and Accessibility	**Q13. Do you find it easy to access school bus stops?** 1. Not at all 2. No 3. Neutral 4. Yes 5. Absolutely
	Q14. If a school bus stop is within a 500m radius from your house (approximately a 5-10 minute walk), would you be willing to use the school bus to commute to school? 1. Yes 2. No 3. Not sure
Cost & Time Saving	**Q15. Do you feel that using school buses helps save costs?** 1. Not at all 2. No 3. Neutral 4. Yes 5. Absolutely
	Q16. Do you feel that using school buses helps save travel time? 1. Not at all 2. No 3. Neutral 4. Yes 5. Absolutely
Safety	**Q17. Do you feel safe using school buses?** 1. Not safe at all 2. Not safe

	3. Neutral 4. Safe 5. Very safe
	Q18. Do you think school bus stops should be located in safe areas? 1. Not at all 2. No 3. Neutral 4. Yes 5. Absolutely

SECTION 4. MOTIVATION, PSYCHOLOGICAL FACTORS & HEALTH BELIEFS AFFECTING SCHOOL BUS USAGE

Please rate your general opinions on the following questions by circling the number corresponding to your response. The rating levels are as follows: **5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree** **1 – Strongly Disagree**						
Q19	**Evaluate the level of control you feel when deciding to use school buses.** **5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree** **1 – Strongly Disagree**					
1	Saves time in picking up and dropping off students	5	4	3	2	1
2	Saves costs compared to personal vehicles	5	4	3	2	1
3	Encouraged by the school to use	5	4	3	2	1
4	Bus stops are near home and easily accessible.	5	4	3	2	1
5	Increases convenience in daily commuting.	5	4	3	2	1
Q20	**Evaluate the factors affecting health beliefs when using school buses.** **5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree** **1 – Strongly Disagree**					

1	Using school buses helps reduce exposure to dust and pollution.	5	4	3	2	1
2	School buses are safer compared to personal vehicles.	5	4	3	2	1
3	Using buses reduces stress from self-commuting to school.	5	4	3	2	1
4	School buses do not ensure hygienic conditions for students.	5	4	3	2	1
5	Walking to school bus stops helps improve student health.	5	4	3	2	1
Q21	**How would the following people react if you use school buses?** **5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree**					
1	Parents (if single) or spouse (if married) will support.	5	4	3	2	1
2	Teachers/School administrators will support.	5	4	3	2	1
3	Friends in class will support.	5	4	3	2	1
4	Neighbors in the community will support.	5	4	3	2	1
5	Elderly in the neighborhood will support.	5	4	3	2	1
Q22	**If school bus stops are placed near your house at the following distances, would you use school buses?** **5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree**					
1	Over 2000m (more than a 20-minute walk).	5	4	3	2	1
2	1500m to 2000m (15-20 minute walk).	5	4	3	2	1
3	1000m to 1500m (10-15 minute walk).	5	4	3	2	1
4	500m to 1000m (5-10 minute walk).	5	4	3	2	1
5	Within 500m (less than a 5-minute walk).	5	4	3	2	1

Q23	**When would you or allow your family use school buses if available?** **5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree**					
1	Could use as early as next week.	5	4	3	2	1
2	Could use as early as next month.	5	4	3	2	1
3	Could use within the next 12 months.	5	4	3	2	1
4	Anytime if the bus stops are conveniently located.	5	4	3	2	1
5	Never.	5	4	3	2	1

SECTION 5. OPINIONS AND EVALUATIONS ON SCHOOL BUS STOP PLACEMENT SOLUTIONS

Q24. Provide your opinion on school bus stop placement solutions? **5 – Strongly Agree 4 – Agree 3 – Neutral 2 – Disagree 1 – Strongly Disagree**						
1	Bus stops must be within a walkable distance.	5	4	3	2	1
2	Bus stops should be located on roads with sidewalks, making it easy for students to walk.	5	4	3	2	1
3	Bus stops should be located in densely populated areas with students.	5	4	3	2	1
4	Bus stops should be placed where buses are not prohibited.	5	4	3	2	1
5	Bus stops should be near public bus and metro stations.	5	4	3	2	1

PHỤ LỤC 2: PHIẾU ĐIỀU TRA PHỎNG VẤN VỀ SỬ DỤNG XE BUÝT TRƯỜNG HỌC TẠI CÁC QUẬN NỘI THÀNH TP. HỒ CHÍ MINH

Người trả lời PV:____________ Vị trí PV:__________ Mã phiếu:_______

Kính chào Anh/Chị/Bạn!

Tôi là Trần Thanh Đại Phúc, học viên thạc sĩ chuyên ngành Quản Lý Đô Thị Thông Minh và Sáng Tạo của Trường Đại học Kinh tế TP. Hồ Chí Minh (Việt Nam) và chuyên ngành Khoa học Giao thông của Trường Đại học Hasselt (Vương Quốc Bỉ). Hiện tại, tôi đang thực hiện đề tài nghiên cứu về việc **Phân bố điểm dừng xe buýt trường học tại các quận nội thành TP. Hồ Chí Minh dựa trên nhu cầu của học sinh cấp 3 bằng phần mềm Hệ thống thông tin địa lý GIS.**

Xe buýt trường học giảm ùn tắc giao thông, thay thế 30-50 xe cá nhân, và là phương tiện an toàn nhất cho trẻ em. Sử dụng xe buýt điện thay diesel còn tiết kiệm chi phí và cải thiện sức khỏe, chất lượng không khí.

Tôi rất mong mọi người có thể dành chút thời gian hoàn thành khảo sát. Tôi xin đảm bảo mọi thông tin sẽ được bảo mật và chỉ sử dụng cho mục đích nghiên cứu.

Mọi góp ý và câu hỏi xin liên hệ email: phuctran.622202211380@st.ueh.edu.vn.
Chân thành cảm ơn Bạn dành thời gian trả lời Phiếu khảo sát này.

PHẦN 1. THÔNG TIN CHUNG

<table>
<tr><td colspan="2">Q1. Giới tính
1. Nam
2. Nữ</td></tr>
<tr><td colspan="2">Q2. Tuổi:
1. Dưới 14 tuổi
2. Từ 10 đến 14 tuổi
3. Từ 14 đến 18 tuổi
4. Trên 18 tuổi</td></tr>
<tr><td colspan="2">Q3. Nghề nghiệp:
1. Giáo Viên/Quản lý nhà trường
2. Học sinh
3. Phụ huynh
4. Khác</td></tr>
<tr><td colspan="2">Q4. Trường học
Trường học có thể là nơi bạn đang làm việc, theo học hoặc có con theo học</td></tr>
<tr><td>Quận 1
1. Trường TH - THCS - THPT Anh Quốc
2. THPT Lương Thế Vinh
3. THPT Năng Khiếu TDTT
4. THPT Chuyên Trần Đại Nghĩa
5. THPT Bùi Thị Xuân
6. THPT Trưng Vương
7. THPT Ten Lơ Man</td><td>Quận 3
1. THPT Nguyễn Thị Minh Khai
2. THPT Lê Quý Đôn
3. THPT Marie Curie
4. THPT Lê Thị Hồng Gấm
5. THPT Nguyễn Thị Diệu</td></tr>
<tr><td colspan="2">Q5. Nơi ở
Nơi ở được khảo sát nhằm định hướng bố trí các điểm dừng xe buýt có thể phục vụ học sinh nhiều nhất có thể.</td></tr>
</table>

Đường ……….……..……..……. Phường ……….……..……..……. Quận …..…..….

PHẦN 2. KINH NGHIỆM SỬ DỤNG PHƯƠNG TIỆN GIAO THÔNG

Q6. Phương tiện chính thường được sử dụng để đi đến trường 1. Đi bộ 2. Xe đạp 3. Xe đạp điện 4. Xe máy 5. Ô tô 6. Xe buýt
Q7. Mức độ tiện lợi của phương tiện giao thông chính bạn sử dụng để đi đến trường? 1. Rất không tiện lợi 2. Không tiện lợi 3. Bình thường 4. Tiện lợi 5. Rất tiện lợi
Q8. Bạn có gặp khó khăn khi sử dụng hoặc để con sử dụng phương tiện giao thông công cộng không? 1. Không bao giờ 2. Hiếm khi 3. Thỉnh thoảng 4. Thường xuyên 5. Luôn luôn
Q9. Thời gian trung bình di chuyển từ nhà đến nơi trường bằng phương tiện giao thông chính của bạn là bao lâu? 1. Dưới 15 phút 2. 15-30 phút

3. 30-45 phút 4. 45-60 phút 5. Trên 60 phút
Q10. Bạn thường xuyên gặp tình trạng ùn tắc giao thông như thế nào? 1. Không bao giờ 2. Hiếm khi 3. Thỉnh thoảng 4. Thường xuyên 5. Luôn luôn

PHẦN 3. HÀNH VI SỬ DỤNG XE BUÝT TRƯỜNG HỌC

Tần suất sử dụng	**Q11. Bạn sử dụng xe buýt trường học bao nhiêu lần mỗi tuần?** 1. 0 lần 2. 1-2 lần 3. 3-4 lần 4. 5 lần trở lên
	Q12. Trong bao lâu bạn đã sử dụng xe buýt trường học? 1. Chưa bao giờ 2. Dưới 1 tháng 3. 1-6 tháng 4. 6 tháng - 1 năm 5. Trên 1 năm
Sự thuận tiện và tính khả dụng	**Q13. Bạn cảm thấy có dễ dàng tiếp cận được các điểm dừng xe buýt trường học không?** 1. Hoàn toàn không 2. Không 3. Bình thường 4. Có

<table>
<tr><td rowspan="2"></td><td>5. Hoàn toàn có</td></tr>
<tr><td>Q14. Nếu có trạm xe buýt trường học cách vị trí nhà bạn bán kính từ 500m trở xuống (khoảng 5-10 phút đi bộ), bạn có sẵn sàng sử dụng xe buýt trường học di chuyển đến trường?
1. Có
2. Không
3. Chưa biết</td></tr>
<tr><td rowspan="2">Tiết kiệm Chi phí và Tiết kiệm thời gian</td><td>Q15. Bạn có cảm thấy sử dụng xe buýt trường học giúp tiết kiệm chi phí không?
1. Hoàn toàn không
2. Không
3. Bình thường
4. Có
5. Hoàn toàn có</td></tr>
<tr><td>Q16. Bạn có cảm thấy sử dụng xe buýt trường học giúp tiết kiệm thời gian di chuyển không?
1. Hoàn toàn không
2. Không
3. Bình thường
4. Có
5. Hoàn toàn có</td></tr>
<tr><td rowspan="2">An toàn</td><td>Q17. Bạn cảm thấy an toàn khi sử dụng xe buýt trường học không?
1. Hoàn toàn không an toàn
2. Không an toàn
3. Bình thường
4. An toàn
5. Hoàn toàn an toàn</td></tr>
<tr><td>Q18. Bạn cảm thấy vị trí trạm xe buýt cần được bố trí an toàn không?</td></tr>
</table>

	1. Hoàn toàn không 2. Không 3. Bình thường 4. Có 5. Hoàn toàn có

PHẦN 4. ĐỘNG CƠ, YẾU TỐ TÂM LÝ & NIỀM TIN SỨC KHỎE ẢNH HƯỞNG ĐẾN HÀNH VI SỬ DỤNG XE BUÝT TRƯỜNG HỌC

Bạn hãy đánh giá ý kiến chung của Bạn đối với các câu hỏi dưới đây bằng cách khoanh tròn vào các có chữ số tương ứng với ý kiến của anh chị. Ý kiến đánh giá của anh chị bao gồm 5 mức: 5 – anh/chị hoàn toàn đồng ý 4 – anh chị/đồng ý 3 – anh/chị không có ý kiến 2 – anh/chị không đồng ý 1 – anh/chị hoàn toàn không đồng ý						
Q19	**Bạn hãy đánh giá mức độ kiểm soát mà anh/chị cảm nhận được khi quyết định sử dụng xe buýt trường học. 5 - hoàn toàn đồng ý 4 - đồng ý 3 – không ý kiến 2 – không đồng ý 1 – hoàn toàn không đồng ý**					
1	Tiết kiệm thời gian trong việc đưa đón học sinh.	5	4	3	2	1
2	Tiết kiệm chi phí so với phương tiện cá nhân.	5	4	3	2	1
3	Được nhà trường khuyến khích sử dụng.	5	4	3	2	1
4	Trạm xe buýt gần nhà và dễ tiếp cận.	5	4	3	2	1
5	Tăng sự thuận tiện trong di chuyển hằng ngày.	5	4	3	2	1
Q20	**Bạn hãy đánh giá các yếu tố ảnh hưởng đến niềm tin về sức khỏe khi sử dụng xe buýt trường học. 5 - hoàn toàn đồng ý 4 - đồng ý 3 – không ý kiến 2 – không đồng ý 1 – hoàn toàn không đồng ý**					
1	Sử dụng xe buýt trường học giúp giảm nguy cơ tiếp xúc với khói bụi và ô nhiễm.	5	4	3	2	1

2	Xe buýt trường học đảm bảo an toàn hơn so với việc di chuyển bằng phương tiện cá nhân.	5	4	3	2	1
3	Sử dụng xe buýt giúp giảm căng thẳng khi tự di chuyển đến trường	5	4	3	2	1
4	Xe buýt trường học không đảm bảo điều kiện vệ sinh cho học sinh.	5	4	3	2	1
5	Việc đi bộ đến các trạm xe buýt trường học giúp tang cường sức khỏe cho học sinh	5	4	3	2	1
Q21	**Những người sau đây sẽ làm gì khi bạn sử dụng xe buýt trường học?** **5 - hoàn toàn đồng ý 4 - đồng ý 3 – không ý kiến 2 – không đồng ý 1 – hoàn toàn không đồng ý**					
1	Cha mẹ (nếu còn độc thân) - vợ/chồng (nếu đã kết hôn) sẽ ủng hộ	5	4	3	2	1
2	Giáo viên/ Quản lý nhà trường sẽ ủng hộ	5	4	3	2	1
3	Bạn bè trong lớp sẽ ủng hộ	5	4	3	2	1
4	Bạn bè trong khu phố sẽ ủng hộ	5	4	3	2	1
5	Người lớn tuổi trong khu phố sẽ ủng hộ	5	4	3	2	1
Q22	**Bạn hãy cho nếu trạm xe buýt được bố trí gần nhà anh chị trong các khoảng cách như dưới đây, anh chị sẽ sử dụng xe buýt học sinh?** **5 - hoàn toàn đồng ý 4 - đồng ý 3 – không ý kiến 2 – không đồng ý 1 – hoàn toàn không đồng ý**					
1	Trên 2000m (trên 20 phút đi bộ từ nhà đến trạm xe buýt)	5	4	3	2	1
2	1500m đến 2000m (15-20 phút đi bộ từ nhà đến trạm xe buýt)	5	4	3	2	1
3	1000 đến 1500m (10-15 phút đi bộ từ nhà đến trạm xe buýt)	5	4	3	2	1

4	500m đến 1000m (5-10 phút đi bộ từ nhà đến trạm xe buýt)	5	4	3	2	1
5	Dưới 500m (dưới 5 phút đi bộ từ nhà đến trạm xe buýt)	5	4	3	2	1
Q23	**Bạn hãy cho biết khi nào thì bạn sẽ sử dụng hoặc cho người thân sử dụng xe buýt trường học nếu được?** **5 - hoàn toàn đồng ý 4 - đồng ý 3 – không ý kiến 2 – không đồng ý 1 – hoàn toàn không đồng ý**					
1	Có thể ngay trong tuần tới	5	4	3	2	1
2	Có thể ngay trong tháng tới	5	4	3	2	1
3	Có thể trong 12 tháng tới	5	4	3	2	1
4	Bất cứ khi nào khi các trạm xe buýt được bố trị thuận tiện	5	4	3	2	1
5	Không bao giờ	5	4	3	2	1

PHẦN 5. Ý KIẾN, ĐÁNH GIÁ ĐỐI VỚI CÁC GIẢI PHÁP BỐ TRÍ TRẠM XE BUÝT TRƯỜNG HỌC

Q24. Bạn hãy cho biết ý kiến của mình về các giải pháp bố trị trạm xe buýt trường học? **5 - hoàn toàn đồng ý 4 - đồng ý 3 – không ý kiến 2 – không đồng ý 1 – hoàn toàn không đồng ý**						
1	Các trạm xe buýt phải có nằm khoảng cách có thể đi bộ được	5	4	3	2	1
2	Các trạm xe buýt phải bố trí tại đường có vỉa hè, dễ dàng cho học sinh đi bộ	5	4	3	2	1
3	Các trạm xe buýt phải bố trí tại các điểm đông dân cư, học sinh	5	4	3	2	1

4	Các trạm xe buýt phải bố trí tại các điểm không cấm xe buýt lưu thông	5	4	3	2	1
5	Các trạm xe buýt phải bố trí gần các trạm xe buýt công cộng, các trạm Metro	5	4	3	2	1

ANNEX 3: INTERVIEW CODES

QUANTITY ANALYSIS CODE TEMPLATE

	SECTION 1. GENERAL INFORMATION					SECTION 2. EXPERIENCE WITH TRANSPORTATION MODES					SECTION 5.
Interview No.	Q1	Q2	…	Q4	Q5	Q6	Q7	…	Q9	Q10	
ID01											
ID02											
ID03											
ID04											
ID05											

QUANLITATIVE ANALYSIS CODE EXAMPLE

No.	Name	Code	Year of Experience	Location	Phone Number
1	Nguyen Van A	GV_1	5	D3W1	0936924208
2	Nguyen Van B	CG_1	10	D1WBN	0936924209
3	Nguyen Van C	QL_1	15	D3W4	0936924210
4	Nguyen Van D	CG_2	20	D3W4	0936924211
5	Nguyen Van E	QL_2	25	D3W7	09369242012

ANNEX 4: DATA PREPARATION

Figure 14. Student density (15-18 years old) of District 1 & 3's wards (personal made by Arc GIS)

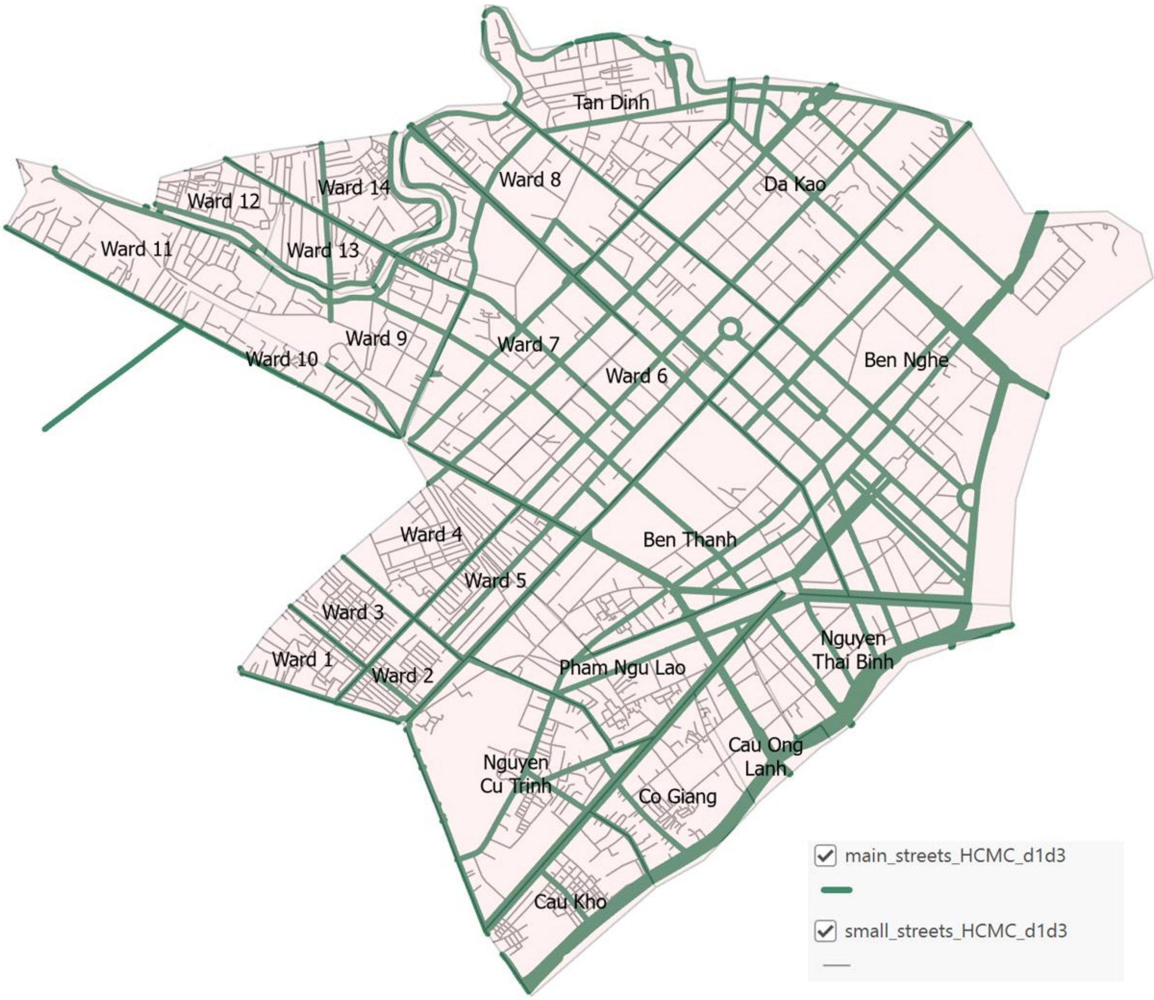

Figure 15. Road Network of District 1 & 3's wards (personal made by Arc GIS) based on Open Street Map data

DATA ASSUMPTON

Table 2 District 1 and District 3 Population of all age and 15-18 years old (Vietnam Census, 2019)

District Name	Ward Name	Pop (all age)	Pop (15-19 years old)
District 1	Ben Nghe Ward	10633.00	579
District 1	Ben Thanh Ward	11714.00	638
District 1	Cau Kho Ward	13706.00	746
District 1	Cau Ong Lanh Ward	10737.00	585
District 1	Co Giang Ward	11517.00	627
District 1	Da Kao Ward	14970.00	815
District 1	Nguyen Cu Trinh Ward	21191.00	1154
District 1	Nguyen Thai Binh Ward	9716.00	529
District 1	Pham Ngu Lao Ward	15183.00	827
District 1	Tan Dinh Ward	23258.00	1266
District 3	Ward 01	13743.00	818
District 3	Ward 10	9166.00	546
District 3	Ward 11	22383.00	1332
District 3	Ward 12	12398.00	738
District 3	Ward 13	6988.00	416
District 3	Ward 14	16265.00	968
District 3	Ward 02	11413.00	679
District 3	Ward 03	10604.00	631
District 3	Ward 04	18930.00	1127
District 3	Ward 05	14408.00	858
District 3	Ward 06	7072.00	421
District 3	Ward 07	13052.00	777
District 3	Ward 09	17472.00	1040

As provided data of Pop (all age) and Pop (15-18 years old) at district level, this reasearch is going to assump the ratio between Pop (all age) and Pop (15-18 years old) at district level are the same in order to calculate the Pop (all age) and Pop (15-18 years old) at ward level.

Population data were primarily obtained from the Vietnam Population and Housing Census (2019), administered by the General Statistics Office of Vietnam. Specifically, the research utilizes two key population indicators at the district level:

- Total population of all age groups (Pop – all age)
- Population of students aged 15–18 (Pop – 15–18 years old)

Due to the absence of detailed ward-level data for the 15–18 age group, the study applies a proportional assumption approach. It assumes that the ratio of the 15–18 age group to the total population at the district level is uniformly distributed across all wards within each district. Using this ratio, the population of 15–18-year-olds at the ward level was estimated proportionally as follows:

$$\text{Pop}_{15\text{–}18,ward} = \left(\frac{\text{Pop}_{15\text{–}18,district}}{\text{Pop}_{all,district}}\right) \times \text{Pop}_{all,ward}$$