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Analysing Travel Patterns at Beirut Arab University, Lebanon: An In-Depth Characterization of Travel Behavior on Campus

Rouba Joumblat [1,*], Hadi Jawad [1] and Adel Elkordi [2]

[1] Faculty of Engineering, Department of Civil and Environmental Engineering, Beirut Arab University, Beirut 1105, Lebanon; hbj204@student.bau.edu.lb
[2] Faculty of Engineering, Department of Civil Engineering, Alexandria University, Alexandria 21544, Egypt; a.elkordi@bau.edu.lb
* Correspondence: r.joumblat@bau.edu.lb

Abstract: Understanding the travel patterns of university campus visitors is crucial for developing effective transportation strategies. Existing research predominantly focuses on student commuting within specific regions, often overlooking the diverse needs of faculty and staff and varying campus contexts. This study addresses a significant gap in the literature by investigating travel behaviors at Beirut Arab University (BAU), which has not been previously studied in this context. BAU's unique situation, with campuses in both urban and rural zones, presents distinct transportation challenges, particularly for those traveling between these areas. Through a comprehensive survey of students, faculty, and staff, this research explores differences in transportation modes, travel distances, durations, and patterns. Statistical techniques, including one-way analysis of variance (ANOVA), Chi-Squared, and McNemar-Bowker tests, reveal significant variations among traveler groups. The findings highlight specific needs, such as improvements in bus services, car-sharing programs, and parking facilities, essential for creating sustainable campus environments. By examining these travel behaviors, the study offers valuable insights into the complexities of campus transportation, contributing new perspectives to the field. The originality of this research lies in its focus on an underexplored area, providing a deeper understanding of how diverse university environments impact transportation choices. This work not only fills a critical void in campus transportation research but also offers practical recommendations for enhancing transportation systems in similar settings.

Keywords: travel mode choice; sustainable transportation system; travel behavior; travel survey; university students; campus mobility; urban campus; rural campus

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1. Introduction

Since the inception of travel-demand modeling in the 1950s, the transportation modeling field has seen significant advancement, enabling planners to better anticipate and enhance various aspects of transportation systems, including safety, efficiency, cost, and accessibility [1]. As metropolitan planning organizations continue to refine their regional travel models by incorporating tailored processes for significant regional generators, there is a growing need to accurately assess the distinctive travel behaviors of university populations. These communities present unique transportation challenges, characterized by a dense concentration of trips during multiple peak periods, driven by the daily activities of students, faculty, and staff [2]. Universities are also increasingly embracing sustainable transportation practices, with campuses often providing environments where alternative transportation modes are both convenient and essential [3].

Despite their significance as trip generators and contributors to regional travel demand, university communities have been underrepresented in traditional travel behavior studies [4]. The travel behavior of university students, in particular, has not received

adequate academic attention, even though they form a substantial and dynamic demographic within many urban areas. This underrepresentation is partly due to the unique challenges associated with surveying this population. Their frequent changes in residence, unconventional living arrangements, and often transient nature further complicate the inclusion of university students in traditional sampling frames, resulting in surveys that fail to adequately reflect their travel patterns [5].

In major metropolitan areas around the world, large universities function as significant travel demand generators. However, unlike the general adult population, university students often possess more flexible and unconventional schedules, such as varying class times and irregular working hours. They also tend to have fewer household or family obligations and lower vehicle availability, which means their travel behaviors can differ significantly from those of the typical adult [1]. These differences make it inappropriate to assume that university students adhere to the same travel behavior patterns as the broader population.

Furthermore, universities create environments that are conducive to research on sustainable travel behaviors, particularly in urban settings with high walkability, bike-friendliness, and transit accessibility. Despite the considerable influence of large urban universities on regional travel patterns, there is a notable lack of research documenting the daily activity-travel patterns of university communities. Consequently, the travel behaviors of university students remain inadequately understood and inaccurately represented, even though they constitute a substantial segment of the population in many regions. Exploring and understanding the travel behaviors of this group is essential for developing more accurate and inclusive regional travel models, revealing critical insights into travel patterns, trip generation, and mode choices that differ from those of the general population [6].

2. Background Literature

Recognizing the significance of assessing and exploring the travel characteristics of university student populations, there have been several recent studies specifically dedicated to measuring and analyzing the travel demand of university students. Zhan et al. employed a web-based travel survey to gather information on students' mode choices across eight distinct universities in China [7]. The results revealed that women exhibited a higher inclination toward using public transit, while men more frequently relied on biking. The study also delved into factors such as bike ownership and travel distance, noting a significant decrease in walking potential with the increase in travel distance. Davison et al. conducted research on cultural variations in travel behavior and mode selection within university campuses in the UK and Ireland [8]. During the academic year 2012–2013, 1049 students from 17 different universities participated in the study's survey. The findings showed that older, female, or part-time students were more likely to utilize cars, while male students showed a higher preference for active modes of transportation. Additionally, the study highlighted the substantial impact of mode choice on the frequency of accessing the campus, indicating that individuals who cycle or walk tend to access the campus more frequently. Furthermore, the research underscored the noteworthy effect of transportation choices on emissions, emphasizing the importance of educating students about their travel alternatives. Additionally, prior research suggests that the mode choice of university students is influenced by factors such as the environment, cost, and travel time. For instance, Whalen et al. investigated the mode choice of students at a Canadian university, revealing that a combination of cost, individual attitudes, and environmental factors, including street and sidewalk density, played a role in shaping students' daily mode choices [9]. Similarly, Rodríguez and Joo conducted a study at the University of North Carolina at Chapel Hill, highlighting that local topography and sidewalk availability were significant factors correlated with the preference for non-motorized modes within the university community [10].

In a comprehensive exploration of factors influencing the travel behavior of university students, Zhou conducted a survey in Los Angeles [11]. The purpose of the study was to

evaluate the connections between age, gender, distance, parking permits, and the ease of getting to and from the institution. A multinomial logit model was created by analyzing the replies of 508 students in order to investigate the factors that influence mode choice. The findings showed that whereas older students tended to use private vehicles, undergraduate and female students were more likely to choose walking or bicycling. Furthermore, there was a positive correlation found between the length of the commute and the rates of carpooling and bus usage. Naturally, having a parking permit was associated with a higher chance of driving a private vehicle. Furthermore, Delmelle and Delmelle examined the travel behavior of 567 students at Idaho University in the USA [6]. The study found that mode choice was highly influenced by travel time to and from the university campus. In particular, people who lived close to the institution were more likely to walk, whereas people who traveled farther than 2.5 km were more likely to utilize private vehicles. The study also found that, especially for men, weather conditions were quite important when choosing a mode. Interestingly, there was a discernible difference in the use of cars between the winter and fall seasons, especially for men.

Several investigations explored the decisions made by students regarding their choice of transportation modes, aiming to identify the potential for a shift in modal preferences. For instance, Miralles-Guasch and Domene delved into the travel behaviors and transportation obstacles faced by university travelers in Barcelona [12]. Using an online survey to gather travel diaries, the study outcomes revealed that the principal obstacles hindering a shift from private cars to non-motorized modes included inadequate infrastructure, the limited emphasis on walking and cycling, and the extended time required for public transport use. In a study conducted by Ripplinger et al., the authors examined the determinants of mode choice among students at North Dakota State University [13]. They developed a mixed multinomial logit model to analyze mode choice on their campus. The results indicated that a potential increase in fuel prices corresponds to a rise in bus ridership. Furthermore, students who own their own vehicles are more likely to use them, whereas others choose the bus service to save money on transportation. Balsas studied how universities persuade visitors to switch from driving to more environmentally friendly forms of transportation [14]. The study conducted surveys on eight campuses in the United States to determine the best strategies used by different colleges to encourage bicycling and walking. One important conclusion was that the greenest college campuses actively promote alternate means of transportation and actively discourage private car use for commuting. Nguyen-Phuoc et al. conducted an evaluation of university students' mode choice in a developing country [15]. A total of 500 randomly chosen students from six different universities in Danang, Vietnam, provided the data. They used a conditional logit regression model to evaluate the variables affecting the method of travel that students choose. The results showed that factors including age, gender, and wealth have a big influence on students' decisions about which mode to choose. Additionally, a negative preference for walking was significantly influenced by journey duration. Students who ride motorbikes have indicated that they would be open to switching to public transportation if an effective and dependable system was available. Some existing literature has witnessed the emergence of activity-based approaches toward comprehending student travel patterns. Moreover, while the general population exhibited a relatively uniform distribution of trips throughout the day, university student trip times displayed a distinct peak in the midday and a higher frequency of trips after 6:00 P.M. Subsequently, a follow-up study utilized an online survey instrument aligned with the NHTS questionnaire and was conducted at Old Dominion University (ODU). The study specifically focused on analyzing student travel concerning the distance between their home location and the campus [16].

Distinguishing various travel behaviors is one aspect, yet transforming someone's travel behavior poses a distinct challenge. To comprehend why certain policy measures gain acceptance while others do not, it is crucial to pinpoint the factors that influence acceptability. Both the characteristics of the transport policy measure and those of the individuals play a pivotal role in achieving acceptability, as highlighted by Eriksson et al. [17]. Numerous

studies have delved into this dimension, exploring alternative solutions aimed at fostering sustainability on university campuses. For instance, Kamruzzaman et al. presented findings from a study conducted at the University of Ulster at Jordanstown in Northern Ireland, utilizing a two-day travel diary and GIS representation to assess student activity spaces [18]. The study revealed that the percentage of student trips made by car exceeded the Northern Ireland average for adults, possibly due to a higher proportion of students owning cars compared to the general population of the country. Predictably, students with car ownership traveled significantly longer distances than those without cars. Notably, low-income students exhibited a greater average activity duration than their high-income counterparts. However, it is important to note that findings from this Northern Ireland study may not be directly applicable to the U.S. context. In 2011, researchers conducted a comprehensive travel survey at Ohio State University (OSU), utilizing the gathered data to predict the transportation modes preferred by OSU students, faculty, and staff [19]. This online survey delved into the typical commuting modes employed by individuals when traveling to campus, while also exploring various strategies aimed at encouraging the increased use of alternative transportation modes. The outcomes of this study revealed a notable trend: students exhibited a greater inclination than faculty or staff members toward adopting alternative modes, including biking and transit, for their journeys to the university campus. This insight contributes valuable information for the development of targeted strategies to promote sustainable and alternative transportation choices within the university community.

Vicente-Molina et al. conducted a recent study to examine the impact of gender on pro-environmental behavior. Their hypothesis was that gender largely influences psychological aspects that are molded by cultural context [20]. Utilizing the responses of 1089 university students, the researchers constructed an ordered logit model to evaluate environmental behavior through a gender perspective. The findings revealed a notable divergence, with distinct factors influencing the pro-environmental behavior of each gender. Men, for example, were shown to have higher elasticity scores, which indicate susceptibility to programs intended to influence behavior. Swiers et al. used a cross-sectional online survey to look into the factors that encourage and hinder cycling among a sample of 194 students at an urban university in the United Kingdom [21]. The findings indicated that enjoyment, fitness improvement, and environmental considerations were the primary motivators for cycling. Conversely, weather and safety concerns emerged as the main barriers, with only a minority of respondents highlighting the anticipated reduction in traffic congestion and pollution.

In a separate attitudinal survey, Rybarczyk and Gallagher examined the reasons students chose the modes of bicycling and walking at the University of Michigan-Flint [22]. The goal was to develop transport demand management solutions that encouraged walking and bicycling on a college campus. To clarify the differences and similarities between groups' reactions to fictitious walking and bicycle conditions, descriptive analysis was utilized. Higher private car expenses encouraged staff members to choose bicycles, but the results also highlighted the vital role that bicycle safety plays in encouraging faculty members to engage in riding. On the other hand, when there was a clear bicycle culture, students were more likely to ride bicycles.

Up to the existing knowledge, there is a scarcity of studies addressing sustainable transportation concerns at university campuses in the Middle East and North Africa (MENA) region. In an attempt to fill this gap, Abubakar et al. conducted a survey involving 152 participants at the University of Dammam, Saudi Arabia, exploring student perceptions of sustainability [23]. The results revealed a high level of awareness and interest among students regarding the sustainability of their university campus. However, there was a notable lack of willingness to actively contribute to achieving sustainability goals. Interestingly, transportation initiatives were found to be fewer in comparison to those related to landscaping and waste conservation. This study underscored the importance of integrating sustainability into campus operations and emphasized the need to train university students

in promoting environmental sustainability in both the Kingdom of Saudi Arabia (KSA) and the broader MENA region.

In a distinct study focused on Lebanon, Aoun et al. represented the sole research exploring sustainable transportation practices. The authors investigated potential strategies for effective, sustainable transportation implementation at the American University of Beirut, Lebanon [24]. The high levels of income and high percentages of car owners in the area made traditional efforts to minimize vehicular travel less successful. According to the study, creating a campus transportation service specifically for high-income travelers—the target population—could prove to be quite successful. The study also highlighted the impact of driving disincentives, like restricted and expensive parking, on the ridership of mass transit. The study suggested dynamic taxi sharing as a novel and creative approach to dynamic mobility. Their mode-shift survey showed that there might be a market for this strategy and that fewer vehicle trips could be beneficially reduced.

Assessing university campus travel patterns provides a unique opportunity to identify this important population group. Hamad et al. (2021) studied the travel behaviors of approximately 2000 individuals. Students, employees, residents, and visitors of Sharjah University City in the United Arab Emirates were evaluated. Each participant completed a carefully crafted survey that gathered data on their socio-demographic details, travel habits, and preferences for commuting to the university campus on a daily basis [2]. The findings confirmed some established travel patterns on campus but also revealed several intriguing insights that could aid university officials and planners in advancing campus sustainability. For instance, as anticipated in a high-income country, most respondents drive alone. There were notable differences in transportation choices between male and female students; women generally show less preference for non-motorized transportation but use the bus significantly more than their male counterparts. Conversely, male respondents utilize more active transport modes compared to women. Key barriers to sustainable transportation on campus include harsh weather conditions and inadequate bus services; improving bus stop convenience and adding air conditioning could potentially increase bus ridership. Unfortunately, some current bus users rely on the service out of economic necessity rather than a commitment to sustainable transport.

Danaf et al. (2014) compared the mode choice patterns of American University of Beirut (AUB) students with those of the Greater Beirut area's general population. Discrete choice models are used to analyze preferences for cars, buses, and shared taxis. Key factors influencing mode choice include travel time, cost, income, auto ownership, gender, and residence location. Wealthier AUB students value their time significantly more than the general population. The models forecast students' commuting preferences under various scenarios to help develop policies promoting more sustainable transportation options [25]. The results demonstrated that increasing parking fees and reducing bus travel time through shuttle services or shared taxis could effectively encourage AUB students to switch from cars to public transport. This study adds valuable insights to the literature on student travel patterns, especially in contexts with high congestion, high car ownership, and poor public transport quality.

To enhance regional travel demand models, transportation engineers and planners aim to accurately represent various subpopulations. University students, a significant group, are often not well understood or adequately depicted in these models. Universities present a distinctive environment for behavioral research due to their livability, support for alternative travel modes, higher density compared to other settings, and diverse transportation options. Data on the travel behavior of university students were gathered and analyzed by Khattak et al. (2011). Using an online survey tool, the study collected information on travel habits, socio-demographic factors, and contextual variables from four major universities in Virginia. The authors provided information about the design and implementation of the survey, the instrument structure, and a descriptive analysis of students' personal and travel characteristics [4]. The findings revealed that the socio-demographic and travel patterns of university students differed from those of the general population. Additionally, variations

in travel behavior were observed between students residing on campus versus those living off campus, as well as between students attending urban campuses and those at suburban campuses. The insights from this study offer a foundation for future research and contribute to a better understanding of travel behavior both within and around university campuses.

Despite a noticeable decline in interest among young adults in obtaining a driving license and owning a car, private vehicles remain the most commonly used mode of transportation in many countries. University students, who frequently travel to their campuses, form a significant portion of the commuting population. Tuveri et al. (2020) conducted a thorough investigation into the tour-based travel behavior of university students, utilizing panel data collected from a sample of students at Roma Tre University. The authors gathered the data during a two-phase panel survey. Between phases, participants received a personalized travel plan to encourage sustainable transport. Daily travel behavior was tracked via a smartphone app that recorded trips in real-time. The data were thoroughly analyzed by categorizing tours based on purpose, time of day, mode of transport, and user characteristics [26]. The analysis reveals that the preferred mode of transport is private vehicles, and that 25% of trips were for non-study purposes, which may hinder the choice of public transportation.

University bus services provide cost-effective transport for students but compete with the convenience of private cars and taxis. Many low-income students rely on these buses, so administrators must improve the service to better support them. Nadimi et al. (2023) explored how university bus services can support social equity and sustainability goals by surveying 303 students at Shahid Bahonar University of Kerman in Iran. They used grounded theory and structural equation modeling to analyze how factors like student characteristics, fleet condition, fares, station quality, and timing influence daily commuting preferences [27]. The study outlines measures for enhancing university bus services, including upgrading the fleet, improving stations, boosting security, and enhancing pedestrian access. Respondents expressed high satisfaction with fare levels, bus security, and waiting times, but women reported feeling discriminated against during commutes. Poor-quality bus services contribute to increased car use and decreased travel sustainability.

Governments implemented various measures to control COVID-19, significantly affecting travel behaviors. Despite this, people still have diverse travel needs, including grocery shopping and commuting to work. Abdullah et al. (2020) studied changes in travel behavior due to COVID-19 using an online survey. They gathered 1203 responses globally, focusing on trip purpose, mode choice, distance, and frequency before and during the pandemic [28]. Results showed significant changes in trip purpose, mode choice, distance traveled, and trip frequency before and during the pandemic. During the pandemic, most trips were for shopping, with a notable shift from public to private and non-motorized transport. People prioritized pandemic-related concerns over general ones when choosing transport modes. Key predictors of mode choice during COVID-19 included gender, car ownership, employment status, travel distance, trip purpose, and pandemic-related factors.

Additionally, a study by Chen et al. (2023) aimed to combine demographic factors, such as gender and culture, with tourists' behavior regarding their choice of travel companions, destinations, and modes of transportation [29]. The research indicates that tourists from other countries have a stronger desire to travel compared to Chinese tourists, who prefer traveling with friends. International tourists are more inclined to use planes and cars, with men showing a more positive attitude towards these modes. Additionally, female travelers from mainland China prioritize trains or buses. These insights could help policymakers and service providers adapt strategies to revive tourism affected by COVID-19.

Generation Z has become a major demographic in urban areas globally, including in developing countries like Indonesia. Representing over a quarter of the population, they are expected to be the largest generation soon. Their significant impact on trip frequency highlights the need to study their travel patterns. This study aims to explore Generation Z's travel habits in urban areas of developing countries, where public transportation is limited and private vehicles dominate. Fisu et al. (2024) investigated Generation Z's travel

behavior, focusing on their trip chains and mileage, using Google Maps Timeline data for 434 individuals aged 17–24 over 153 days (August to December 2022). This method offers an alternative to the traditionally short-term and costly travel diary surveys, which are prone to errors. The analysis, considering factors like gender, financial status, and location, revealed 213,094 trips, with 63% by motorcycle and 35% by car, while walking, cycling, and public transport accounted for only 2% [30]. The results showed that men took more daily trips and traveled greater distances than women on both weekdays and weekends. Weekday trips were generally more frequent than weekend trips. Additionally, Generation Z individuals with higher financial means made more daily trips, particularly on weekends, with those earning above IDR 2.4 million (>USD 156.37) traveling more on weekends. Regression analysis revealed that gender and financial status significantly affected daily trips and mileage, with home and workplace or campus locations also playing a role.

Research Gaps

Numerous studies have explored transportation challenges at universities worldwide, primarily focusing on students' commuting patterns within specific regions or countries. While these studies emphasize the importance of understanding travel behavior on campus as a prerequisite for changing travel habits and addressing transportation issues, their findings often lack applicability across different campuses due to varying social, cultural, and economic conditions, as well as campus-specific factors such as location, size, transportation amenities, and infrastructure. This has resulted in a significant gap in the literature concerning comprehensive studies on travel behavior across diverse institutions and geographic locations.

This research aims to address this gap by focusing on Beirut Arab University (BAU), an institution that has not been previously studied in this context. BAU's unique situation, with campuses situated in both urban and rural zones, presents distinct transportation challenges, particularly for students who must travel between these campuses. By examining the travel behaviors of students, faculty, and staff at BAU, this study provides valuable insights that are crucial for understanding and improving transportation systems within similar university environments. The originality of this study lies in its exploration of this uncharted area, offering new perspectives and filling a critical void in the field of campus transportation research. This research not only contributes to a fuller understanding of travel behavior patterns but also addresses the unique transportation challenges faced by different campus environments.

3. Research Objectives

The presented research aims to evaluate the activity–travel engagement patterns of an often-overlooked population of road users. It is imperative for the transportation industry to acknowledge and comprehend the travel behaviors of this emerging demographic to effectively identify and provide the necessary services required to meet the upcoming demand. Numerous researchers have delved into transportation issues at university campuses, which mostly underscore the significance of delineating travel behavior at a university campus as a preliminary step toward influencing travel behavior and resolving transportation challenges. Moreover, a considerable portion of these studies analyses the travel behavior and preferences of university students within specific regions or countries, which makes the findings derived from these investigations not applicable to other campuses due to different social, cultural, and economic variations, as well as factors related to the university itself, including geographic location, size, transportation facilities, and infrastructure.

Thus, it is crucial to explore the travel behavior within Beirut Arab University (BAU), a hub hosting multiple academic institutions with an academic population of around 5000. The study endeavors to furnish university administrators and city planners with a thorough examination of the travel patterns in the campus vicinity, thereby aiding in the formulation of sustainable policies, programs, and infrastructure. Undoubtedly,

the insights and recommendations derived from this study are expected to be valuable not only for other universities in the region but also for institutions globally. Through statistical analysis encompassing socio-economic, demographic, and travel characteristics of university students, the primary research question seeks to ascertain whether the travel behavior of this group differs from that of the broader population and, if so, the extent of those differences. To address this, the study comprehensively analyses and compares trip generation aspects, modal choices, and departure time decisions of university students with statistical data for the general population in Lebanon.

4. Description of the Study Area

This study delves into the travel behaviors of Beirut Arab University (BAU) students, employees, and academic staff, within two of its campuses: the Beirut campus in Greater Beirut Governorate and the Debbieh campus in Mount Lebanon Governorate in Lebanon. The following section furnishes a comprehensive depiction of the research areas, commencing with an overview of the location and distinctive features of BAU. Subsequently, it engages in a discourse on the noteworthy transportation-related challenges encountered at BAU.

The geographical boundaries of Beirut and Debbieh campus are illustrated in Figures 1 and 2, respectively.

Established in 1960, the Beirut campus serves as the main branch of BAU, centrally located in the heart of Beirut on Tareek El Jadida. Encompassing a land area of 41,107 m^2, it features two buildings with a total built area of 50,500 m^2. The primary structure, spanning 22,000 m^2, houses BAU administration and the faculties of business administration and dentistry.

Within this campus, there is a 300-seat festivities hall, five well-furnished seminar rooms equipped with multimedia and display screens, a specially designed "Al Multaqa" serving as a center for cultural and art activities, a student activities and alumni and career office building, a gymnasium, a sports hall, and a cafeteria.

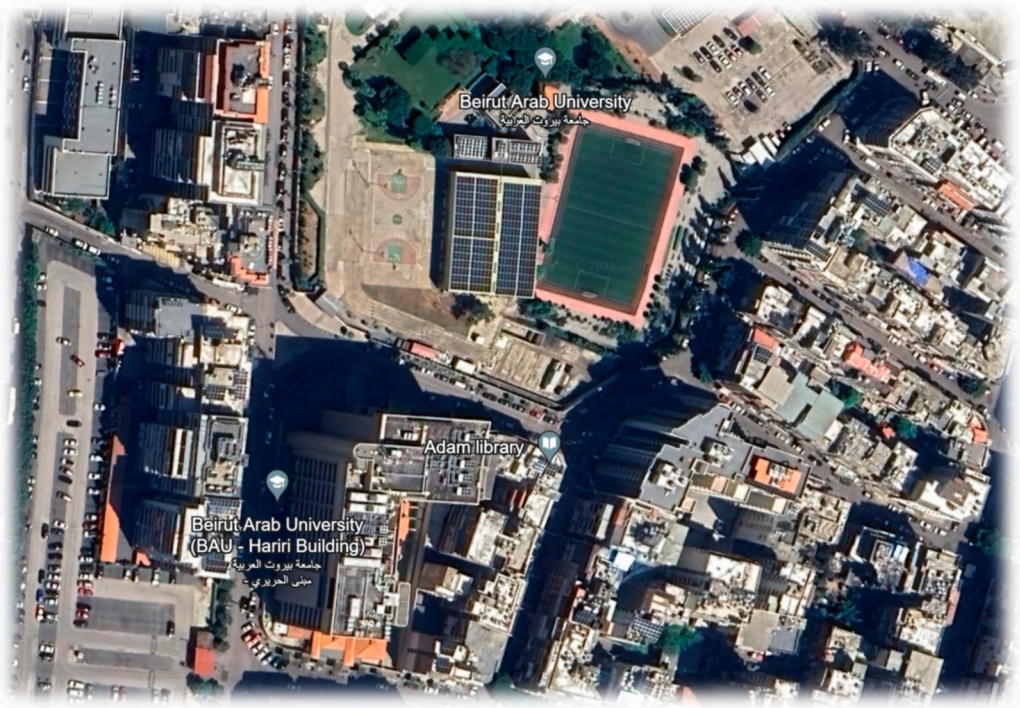


Figure 1. Geographical boundaries of the BAU-Beirut campus.

Figure 2. Geographical boundaries of BAU-Debbieh campus.

The second building is the Hariri building, a 12-story structure with two basements and a ground floor, occupying 28,000 m^2. It accommodates five faculties: human sciences, law and political science, pharmacy, medicine, and health sciences. The Beirut campus offers a publicly accessible parking area designated for students, faculty, and visitors alike.

Established in 2006, the Debbieh campus is situated 33 km away from Beirut city. Covering an expansive land area of 1,353,000 m^2, the total built area encompasses 52,538 m^2.

This campus includes four buildings dedicated to faculties and administration, two structures for student dormitories, two buildings for staff accommodations, a gymnasium, a mosque, an astronomical observatory, a cafeteria, an open theater, and a student lounge.

At present, the campus hosts three faculties: architecture—design and built environment, engineering, and science. The Debbieh campus has allocated four dedicated parking areas within the campus premises to accommodate the parking needs of its students, staff, and visitors.

The utilization of the public parking facility, which accommodates the private cars of students, staff, and members, as well as those of any person visiting the area, has given rise to a parking shortage issue at BAU, particularly at the Beirut campus. The inclusive nature of the parking space, while aiming to cater to a diverse range of individuals, has inadvertently led to increased demand, surpassing the available parking capacity. The resultant shortage poses a challenge for the university community and visitors alike, impacting the overall convenience and accessibility of parking on the Beirut campus. On the other side, while the parking challenge may not be as pronounced at Debbieh campus, it presents a different set of concerns. Attracting students from various governorates in Lebanon, many travelers face an average driving time of 20–30 min to reach the campus. Despite the university's effort to alleviate transportation issues by providing shuttle buses specifically from Beirut and Saida cities, several factors, such as crowdedness, areas not covered by shuttle services, and the absence of intelligent transportation assets, contribute to discouraging travelers from adopting this mode of transportation. These challenges highlight the need for a comprehensive and efficient transportation strategy to better serve the diverse commuting needs of students and staff attending the Debbieh campus.

5. Methodology

5.1. Questionnaire Description

Figure 3 illustrates the process of data collection and analysis employed in the study. A comprehensive travel survey was conducted among the target population, including students, employees, and academic staff, in order to gather detailed information on travelers' trips to, within, and departing from the Beirut and Debbieh campuses of BAU. For this reason, during the 2023–2024 academic year, a thoroughly designed survey was distributed online to individuals commuting to both campuses between the fall and spring semesters.

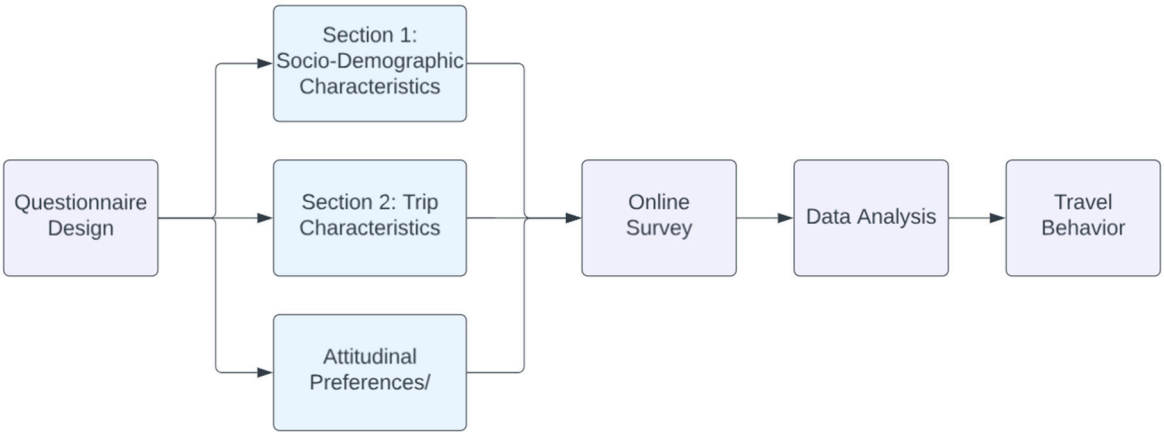


Figure 3. Theoretical framework of the study.

Before its dissemination, a preliminary study was conducted to formulate a concise and effective questionnaire. The questionnaire was designed in order to comprehensively understand the activity-travel patterns of the targeted population and capture all travel demand within and around both university campuses. For this reason, the survey, outlined in Table 1, comprised three sections addressing socio-demographic characteristics, trip characteristics, and perceptions of transportation-related issues on both campuses. Utilizing an internet-based platform, the survey was developed and administered. The survey, customized to align with the research requirements, was created using Google Forms. This approach enabled participants to easily access and complete the survey from any location with internet connectivity. Their responses were automatically compiled and stored in a spreadsheet for subsequent analysis. This method provides a dependable and streamlined means of data collection, reducing errors and biases typically associated with paper-based surveys. Respondents entered their data online, which was automatically compiled into a database for subsequent cleaning and analysis.

The initial section of the questionnaire concentrated on socio-demographic factors, encompassing age, gender, nationality, location of the campus attending, occupation or employment status, main mode of travel to BAU campus, living place when the classes are held and some household information including number of licensed drivers and car ownership. The survey's second section investigated participants' trip characteristics and mode preferences. It included inquiries about the trip purpose, frequency of work/study trips, origin starting place (governorate) and destination (governorate), total trip in-vehicle and out-of-vehicle trip duration and length.

The final section of the questionnaire aims to gather insights into travelers' perspectives on transportation-related issues. If respondents indicated they use public transport, they were required to list the reasons for this choice. Conversely, those favoring private cars were asked about reasons for not considering public or active transport. Furthermore, participants were queried about their perspectives on resolving issues related to parking facilities and shortages. They were also prompted to share sustainable strategies to discourage solo driving, suggest smart transportation technologies suitable for everyday

use, and propose additional transportation options or enhancements to be considered for implementation on campus in the future.

Table 1. Questionnaire's main categories and inquiries.

Classification	Element in Question
Socio-demographic Characteristics	Gender
	Age
	Nationality
	Campus attending
	Occupation or employment status
	Travel mode to BAU
	Number of licensed drivers in a household
	Number of vehicles in a household
	Living place (when the university classes are held)
Trip Characteristics	Trip purpose
	Frequency of campus attending trips/number of trips
	Starting place (origin)
	Destination
	Trip length (Km)
	Trip duration (in-vehicle and out-of-vehicle) (min)
Preferences	Regular bus drivers' opinion on public transportation services
	Non-regular bus drivers' opinion on public transportation services
	Opinion to stop driving alone
	Opinion to solve the parking shortage problem
	Opinion on public transportation services to/from university
	Preferences on smart transportation technologies
	Preferences on additional transportation options/improvement at BAU

Across certain questions, participants were allowed to select multiple options in the survey, enabling them to express a range of preferences and behaviors. This approach provided a more comprehensive understanding of their choices and allowed for a richer analysis of the data.

5.2. Sample Size

This study used the survey sample directly, with no sample weighing or population synthesis included. All of the responses were methodically tallied in a database before the analyses. The supplied data was carefully examined to ensure its dependability and applicability. In total, 400 final survey responses—which had undergone thorough cleaning, error checking, and the removal of most incomplete and duplicate responses—were used in the study.

The Cochran sampling technique was employed to compute the necessary sample size based on the desired level of precision, confidence level, and the estimated proportion of the attribute within the population. This formula is particularly well-suited for large populations [31,32]. The formula is widely used for calculating sample size with a simple random sampling design. Hence, the study's sample size was determined through the application of the Cochran formula, represented in Equation (1), with the goal of achieving

a 95% confidence level (i.e., $Z = 1.96$) and p-value of 50% and ±5% confidence interval. This led to a minimum respondent count of 385.

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

where,

n is the required sample size.
Z is the Z-score corresponding to the desired level of confidence.
p is the percentage of picking a choice and,
E is the desired margin of error.

6. Results and Discussion

6.1. Sample Analysis

Travelers from BAU were classified based on their projected travel behavior, taking into account factors such as gender, citizenship, profession, and car ownership. The study examined various aspects of travel patterns, including trip generation, mode of travel, travel time and distance, trip production and distribution, and the perspectives of travelers. The research used descriptive analysis to illustrate the obstacles and incentives that affected the selection of sustainable transportation methods and investigated the possibility of changing travel modes within the BAU community. To ensure the accuracy of the study, it is crucial to analyze the collected sample, confirming that the responses are representative of the entire BAU population and identifying any potential biases.

Figure 4 presents the breakdown of the sample by gender, age, citizenship, occupation, campus attending, faculty, and occupation or study level, while Figure 5 demonstrates the interaction of various characteristics among the respondents in relation to car ownership.

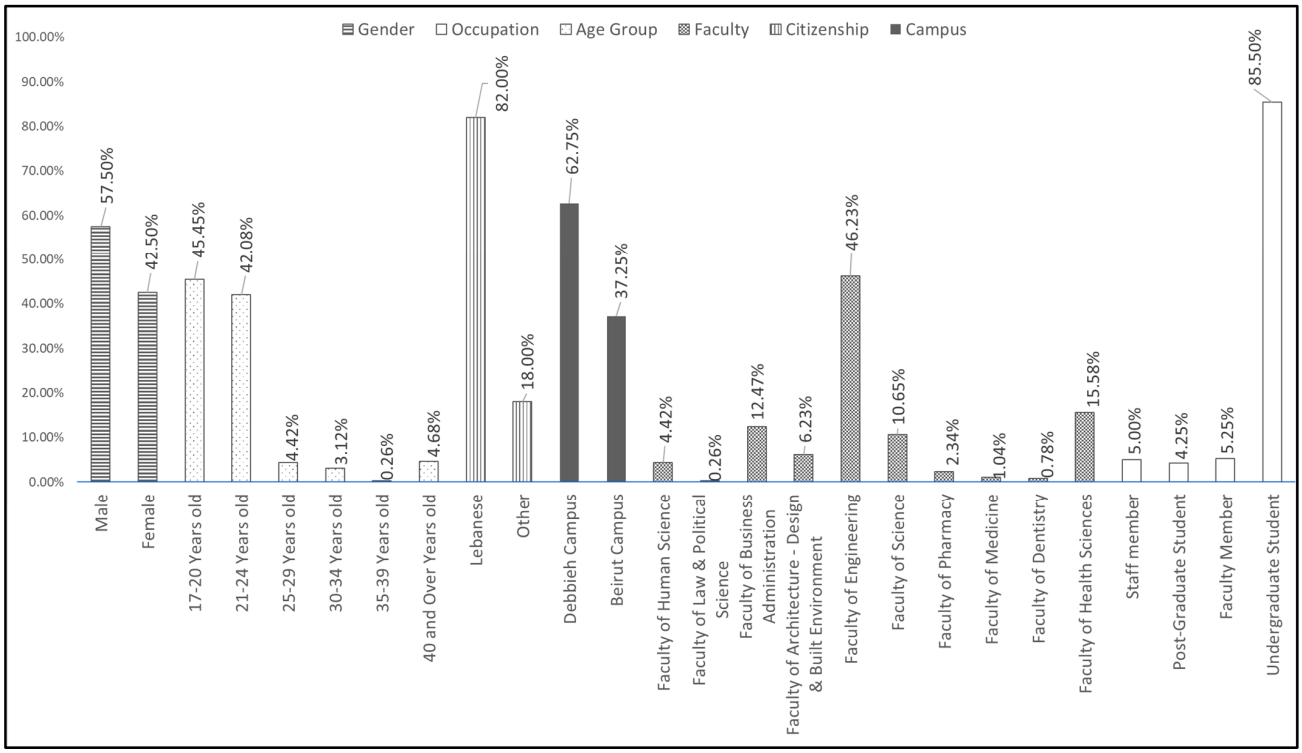


Figure 4. Sample breakdown by gender, age, citizenship, occupation, age, campus attending, faculty, and occupation level.

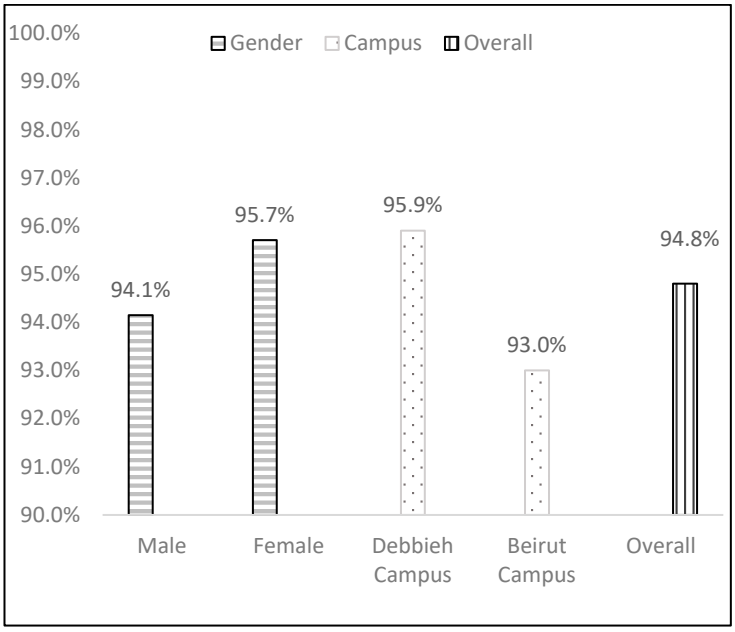


Figure 5. Percentage of the population that owns a car, with the split shown across gender and campus.

A bias was observed towards users from the Debbieh campus (62.75%) compared to users from the Beirut campus (37.25%), whereas in the BAU population, 69.9% of the students are from the Beirut campus, and only 30.1% are from the Debbieh campus. The sample also underrepresented graduate users, who, make up 10.8% of the student population, but only constituted 4.7% of the student respondents. Despite these biases, the overall distribution of survey respondents was deemed acceptable.

Respondents were asked to disclose the number of vehicles in their households. The data revealed that 23.6% of respondents reported owning more than two vehicles, 41.6% owned two, and 29.6% had just one vehicle. A small group of 20 respondents, representing 5.2%, reported no vehicle ownership, reflecting the previously high economic status in the country. Both male and female respondents exhibited similar rates of car ownership, with 94.1% of men and 95.7% of women owning cars. Comparable car ownership rates were also observed among respondents from both the Debbieh and Beirut campuses, at 95.9% and 93.0%, respectively.

6.2. Travel Characteristics

Figure 6 shows the distribution of travel modes among BAU users. The most common mode is driving alone, with 36% of the respondents choosing this option. This is significantly lower than the 96% reported by a previous study conducted by Abou Ali et al. on student travel behavior [33]. Carpooling is the second most popular mode, with 18.4% of the respondents sharing their rides. About a quarter of the respondents (23.9%) use the BAU bus service, which is a paid service for students and staff. Public transportation and taxis are also used by some respondents, with 22.3% and 10.4%, respectively. Active transport, such as walking or cycling, is another mode that is rarely used, with only 11% of the respondents opting for it. Travel by motorcycle is the least common mode, with just 7.3% of the respondents utilizing it in their journey to campus.

Figure 7 compares the mode choices of the respondents from both campuses and genders. The most popular mode for Debbieh campus respondents was driving alone (41.5%), followed by the BAU bus service (36.9%). Car sharing was the third most common mode (20.7%), which is more sustainable than driving alone. On the other hand, the most popular mode for Beirut campus respondents was public transport (34.0%), followed by driving alone (27.1%) and active transport (22.2%), such as walking or cycling. The

difference between the two campuses can be attributed to the area classification: the Debbieh campus is in a rural area, while Beirut campus is in an urban area with better pedestrian and public transport access.

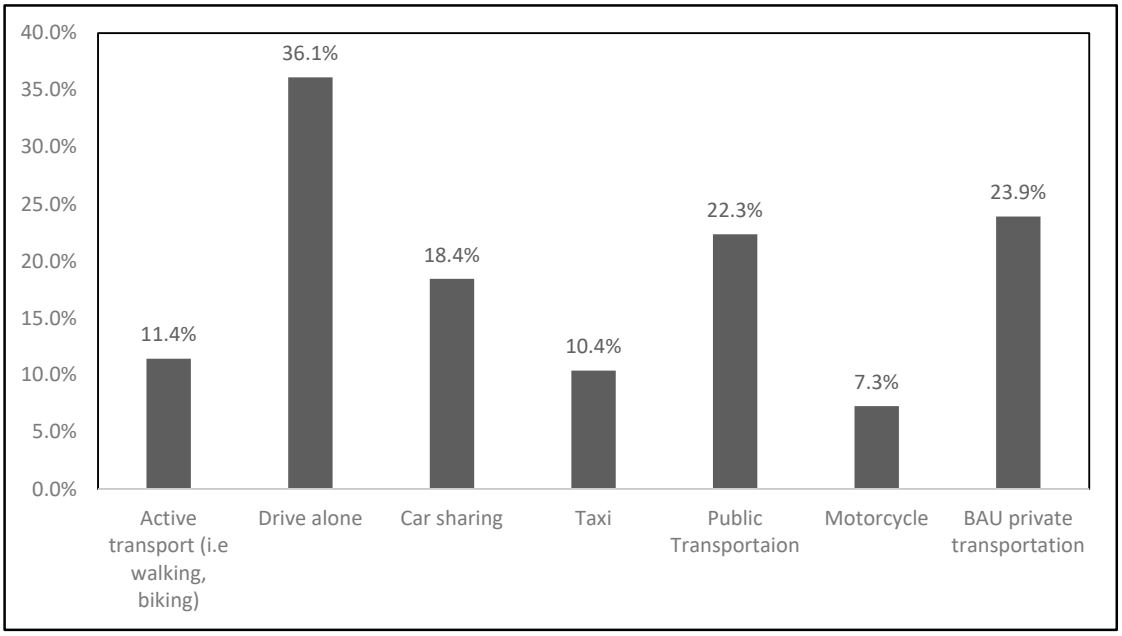


Figure 6. The travel modes utilized by BAU respondents.

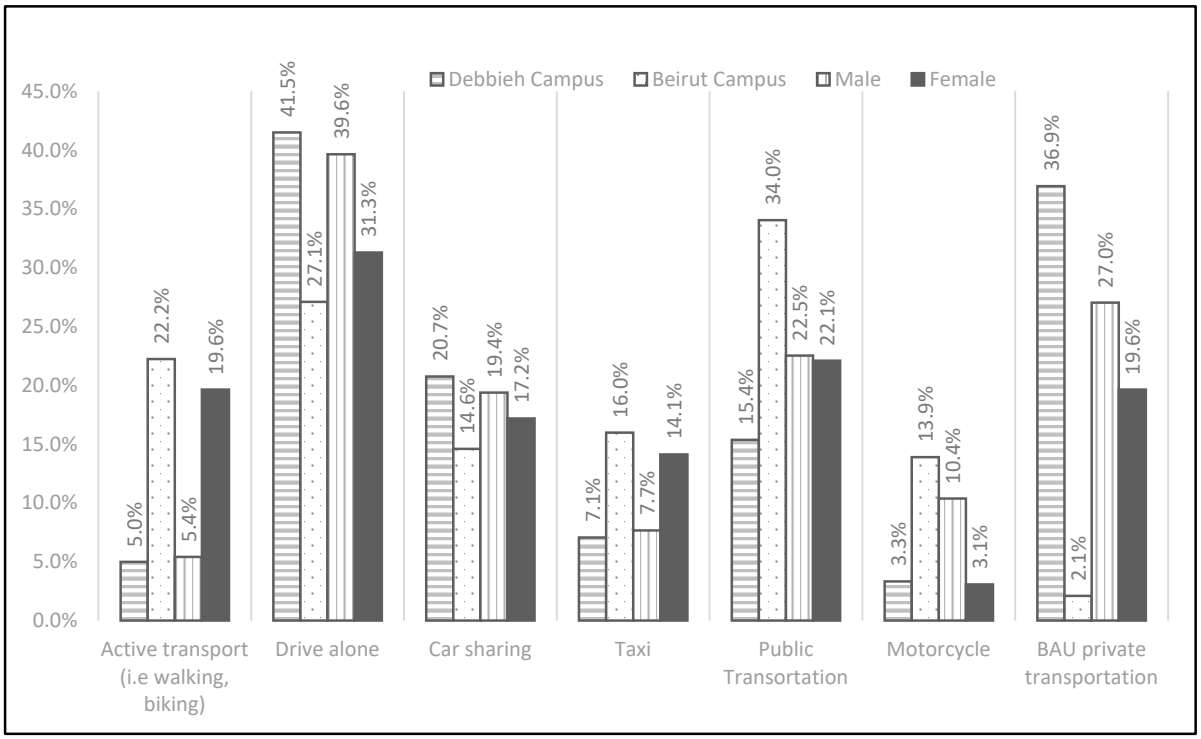


Figure 7. Travel mode choice, based on campus and gender.

Driving alone was also the most common mode for both genders, with 39.6% of men and 31.3% of women choosing this option. However, there were some gender differences in the other modes: women used active transport and taxis more than men, while men used the BAU bus service and motorcycles more than women. Car sharing and public transport had similar shares for both genders.

These results highlight a significant difference between the general population and university students. Al-Shaar et al. (2022) found that 69% of the surveyed general population used private vehicles for their commute, with psychological factors playing a role in their preference for private transport [34]. In contrast, university students, who are typically younger, may be more open to using public transportation.

Figure 8 illustrates the trip purposes of the respondents from both campuses. The main reason for traveling to BAU was attending classes, which accounted for 90.6% of all trips. Other trip purposes included library or study sessions (18.7%), work (17.1%), social events (14.5%), physical activities (12.5%), and others (5.5%). The respondents were able to choose more than one purpose for each trip.

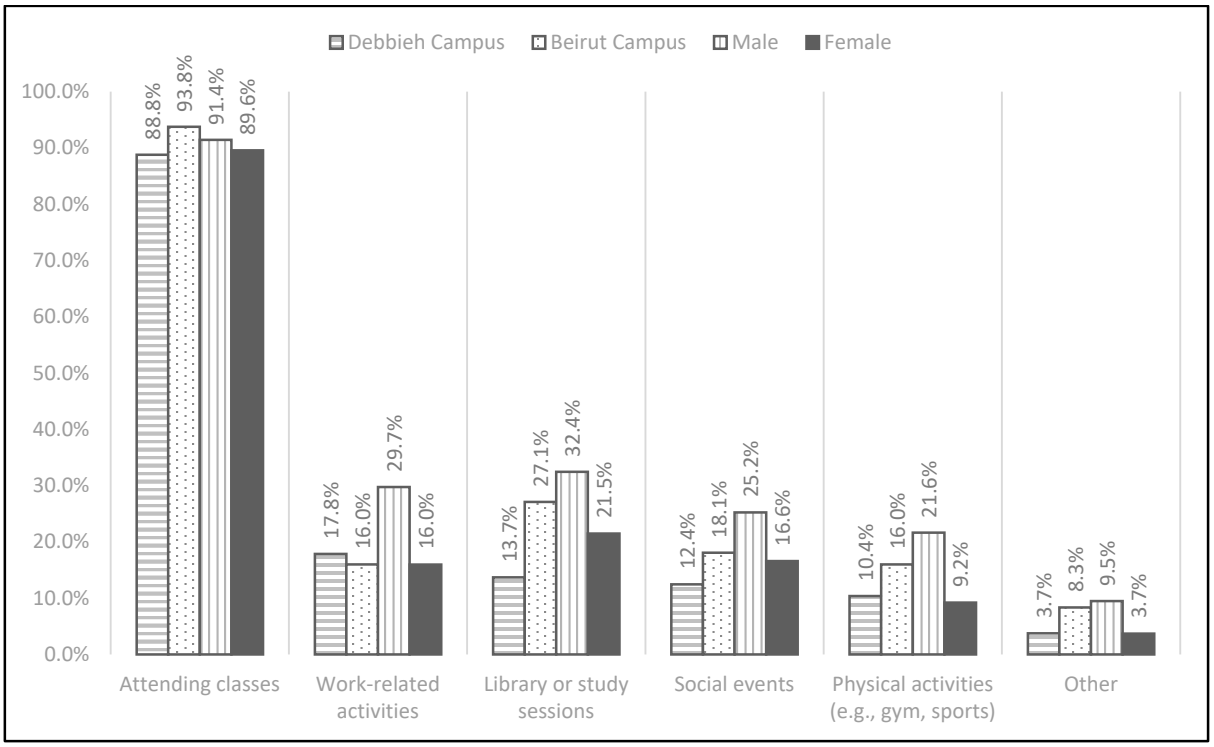


Figure 8. Purposes of trips to campus.

Driving alone was the most common mode for work trips (34.6%), followed by the BAU bus service (30.8%). For attending classes, driving alone and public transport were equally popular (27% each). Active transport, such as walking or cycling, was mostly used for physical activities (38.9%) and social events (28.6%). Taxi and motorcycles were the least common modes for all trip purposes.

Statistical Analysis

Different statistical tests were used in this study in the aim of assessing the statistical significance of differences among various groups of BAU travelers namely One-way Anova, Chu-Square and Mcnemar-Bower tests.

The Chi-Square test is utilized to determine if there is a significant association between two categorical variables, making it particularly useful for examining relationships between traveler groups and their characteristics. McNemar's test is designed to assess changes in responses for paired categorical data, providing insight into whether there is a significant difference before and after a specific intervention or over time.

The one-way ANOVA test, on the other hand, is used to compare the means of three or more independent groups to determine if there are statistically significant differences among them. In this study, it facilitated the identification of variations among distinct traveler groups, highlighting key differences that align with the scope of our research.

One-way ANOVA test was conducted with a 95% confidence interval, meaning that a factor was considered statistically significant if the significance value, α, was less than 0.05. Table 2 displays the statistical results of the *p*-values conducted in one-way ANOVA.

Table 2. Statistical tests *p*-values.

Mode of Transport	**Test**	***p*-Value**			
Active Transportation		Gender	Occupation	Citizenship	Campus
Drive alone	ANOVA	0.031 *	0.0001 *	0.308	0.023 *
Car sharing	Chi-squared	0.000012 *	0.675	0.000138 *	2×10^{-25}
Taxi	Mcnemar–Bowker	0.0045 *	0.33186	0.4619	0.00097 *
Public Transportation	* Statistically significant				
Motorcycle					
BAU shuttle bus					

A chi-square Test of independence was conducted to examine the relationship between traveler characteristics and travel mode. The results indicated that there was a significant association between the two variables.

Additionally, a Mcnemar–Bowker test was applied to the results; these tests were selected to obtain results for multiple categories.

The results indicated that there were statistically significant differences among the various BAU groups. These differences were assessed in terms of gender, occupation, citizenship, and the location of the campus by the various modes of transportation.

The results revealed that the differences were statistically significant among BAU groups based on gender, occupation of the traveler, and whether attending the rural or the urban campus considering various modes of transportation with a *p*-value of 0.031, 0.0001, and 0.023, respectively, from the ANOVA test. However, the results revealed that the differences were statistically insignificant among BAU travelers based on their citizenship, with a *p*-value of 0.308, while the chi-squared test showed it to be statistically significant, with a *p*-value of 0.000138.

Thus, it can be stated that the characteristics of travelers have a significant impact on their mode-choice decisions. This suggests that these socio-demographic factors play a role in influencing travelers' decisions regarding transportation modes.

The findings align with previous studies by Nguye-Phuoc et al. and Shi et al. [15,35] indicating consistency with prior research on the influence of traveler characteristics on mode choice.

6.3. Perceptions Regarding Transportation Issues on Campus

The purpose of the BAU travel questionnaire was to determine the respondents' preferences and attitudes regarding a range of transportation-related matters at BAU, particularly those that deter them from utilizing more environmentally friendly forms of transportation rather than private vehicles. This analysis will assist in identifying a few of the campus transportation issues and offer suggestions for solutions.

One of the questions asked the respondents who used private cars to travel to BAU about the reason(s) behind their choice. The most common reason was the availability of a private car, chosen by 31.2% of the respondents. The second most common reason was shorter travel time, chosen by 27.3% of the respondents. Similarly, Al-Shaar et al. found that time was a prevailing factor in the choice of private car among the general Lebanese population [34]. Meanwhile, the third most common reason was the inconvenient schedule of the bus, chosen by 23.1% of the respondents. Other reasons included weather conditions (13.8%), safety concerns (11.7%), cost considerations (10.4%), inadequate bus infrastructure (10.2%), and parking availability (6.2%). Some respondents chose more than one reason, so the percentages add up to more than 100%. Figure 9 shows the distribution of the reasons by campus and gender. There were some differences between the campuses and genders in

the reasons. For example, Debbieh campus respondents were more likely to choose shorter travel time than Beirut campus respondents, while Beirut campus respondents were more likely to choose inadequate bus infrastructure than Debbieh campus respondents. Female respondents were more likely to choose safety concerns and taxis than male respondents, while male respondents were more likely to choose the BAU bus service and motorcycles than female respondents.

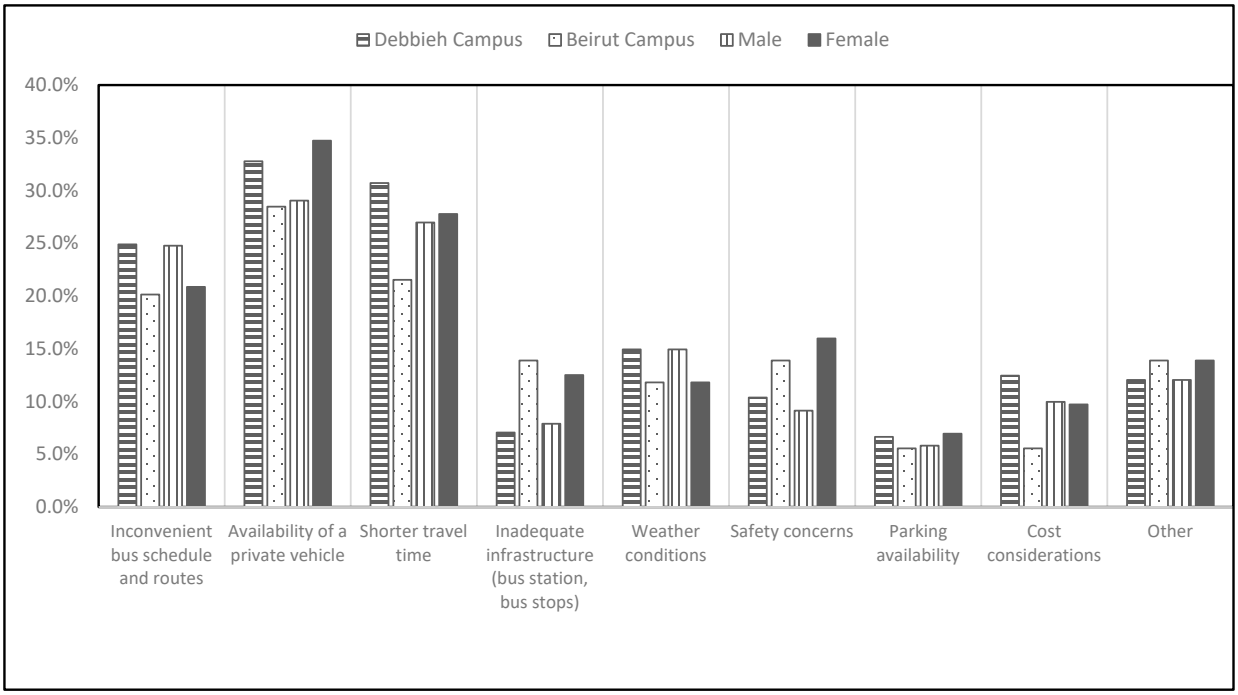


Figure 9. Reasons for using private cars from both campuses and genders.

The respondents who used the BAU bus services and public transport regularly were also asked about their choices. The main reason was the service's cost-effectiveness, which 32.2% of the respondents picked. The second reason was not having a private vehicle, which 24.4% of the respondents picked. The other reasons were convenience, accessibility, limited parking, environmental sustainability, and others, which ranged from 5.5% to 11.1%. The respondents could pick more than one reason, so the percentages are over 100%. The reasons varied by campus and gender. Figure 10 compares the reasons by campus and gender. For instance, more men than women picked not having a private vehicle, while more women than men picked accessibility, convenience, environmental sustainability, and others. Compared to Debbieh campus respondents, more Beirut campus respondents picked accessibility, limited parking, environmental sustainability, and other, while more Debbieh campus than Beirut campus respondents picked the service's cost-effectiveness.

Figure 11 displays the satisfaction levels of the respondents with the parking, bus service, and public transportation at BAU. The respondents were asked to rate their satisfaction on a scale of 1 to 5, where 1 means very dissatisfied and 5 means very satisfied. The majority of the respondents were neutral (3) for all three aspects, so we compared the positive (4 and 5) and negative (1 and 2) ratings to determine the opinion. For this, Figure 11a shows that the respondents were slightly more satisfied than dissatisfied with the parking, with 30% giving positive ratings and 24% giving negative ratings. Additionally, Figure 11b shows that the respondents were more satisfied than dissatisfied with the bus service, with 33% giving positive ratings and 13% giving negative ratings. Similarly, Figure 11c shows that more respondents see public transportation as accessible than inaccessible, with 34% giving positive ratings and 23% negative ratings.

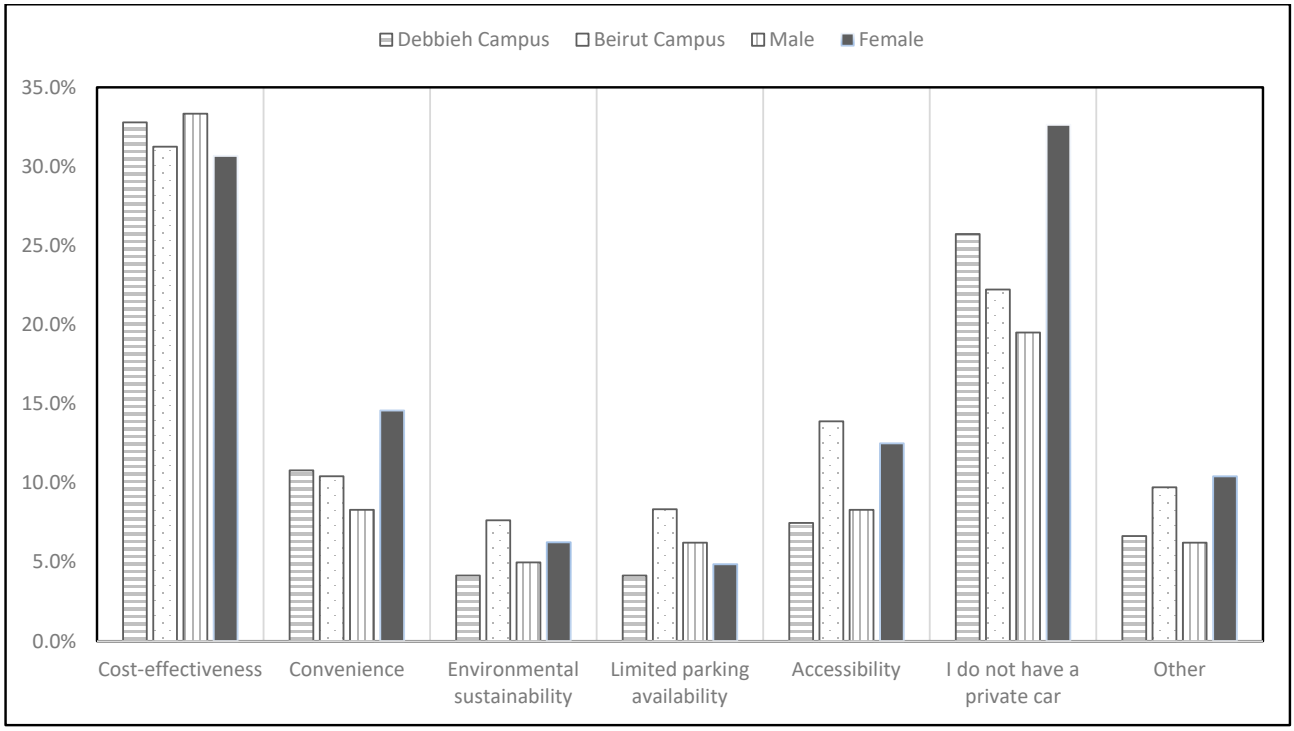
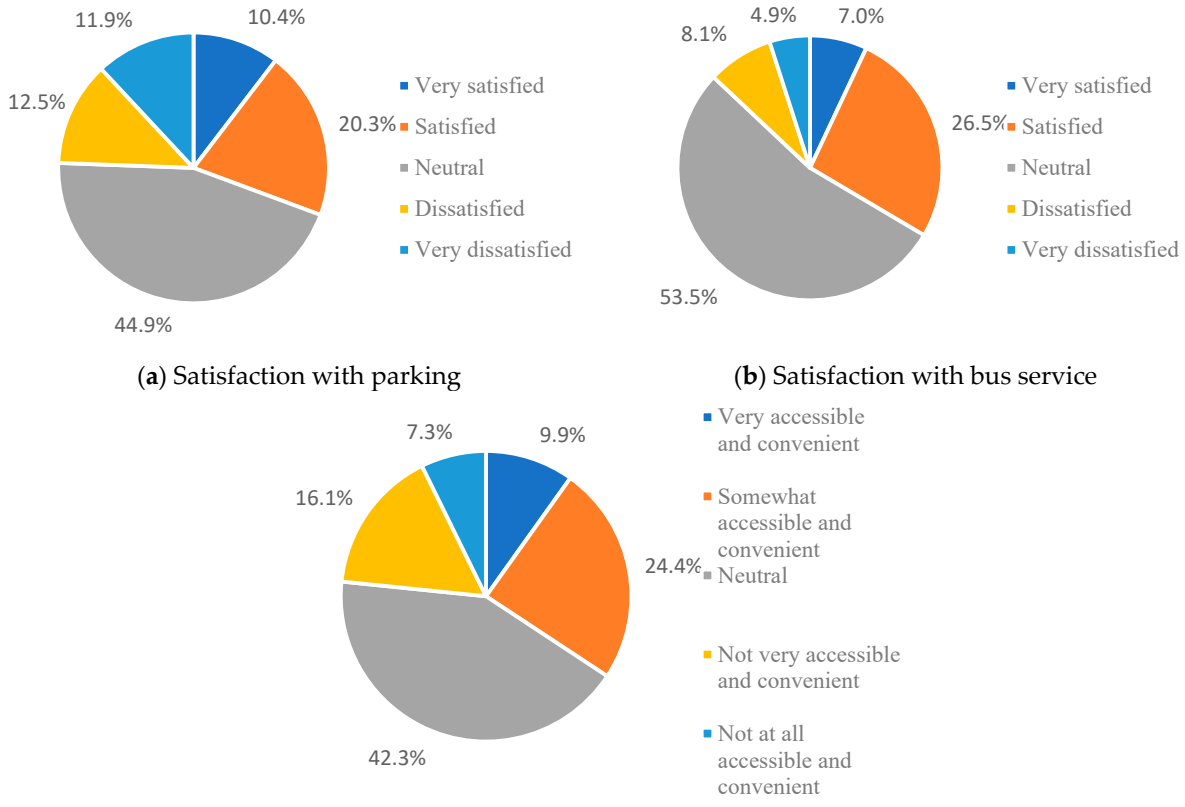


Figure 10. Reasons behind using the BAU bus service, and public transportation based on campus and gender.



(**a**) Satisfaction with parking

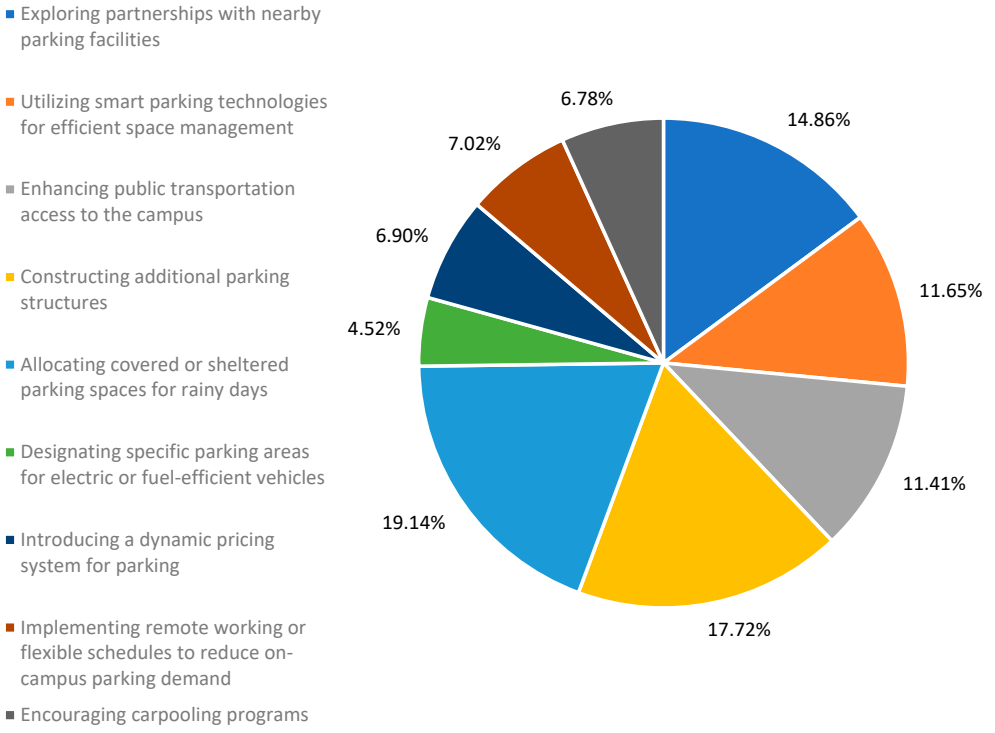
(**b**) Satisfaction with bus service

(**c**) Accessibility of with public transport

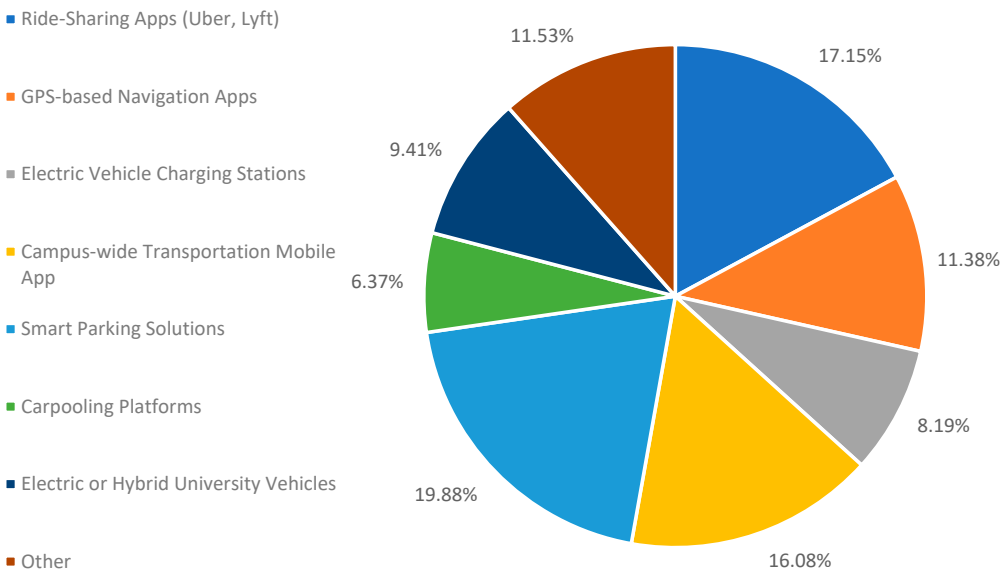
Figure 11. Satisfaction levels of the respondents with the parking, bus service, and public transportation at BAU.

6.4. Suggestions for Proposed Actions

The survey conducted at BAU focused on identifying potential solutions to pressing transportation-related issues. The survey targeted various areas including parking problems, the adoption of smart transportation technologies, and improvements to be implemented on campus. It also explored options that would encourage private car users to switch to more sustainable travel modes. The results, presented in Figure 12, suggest several recommendations.

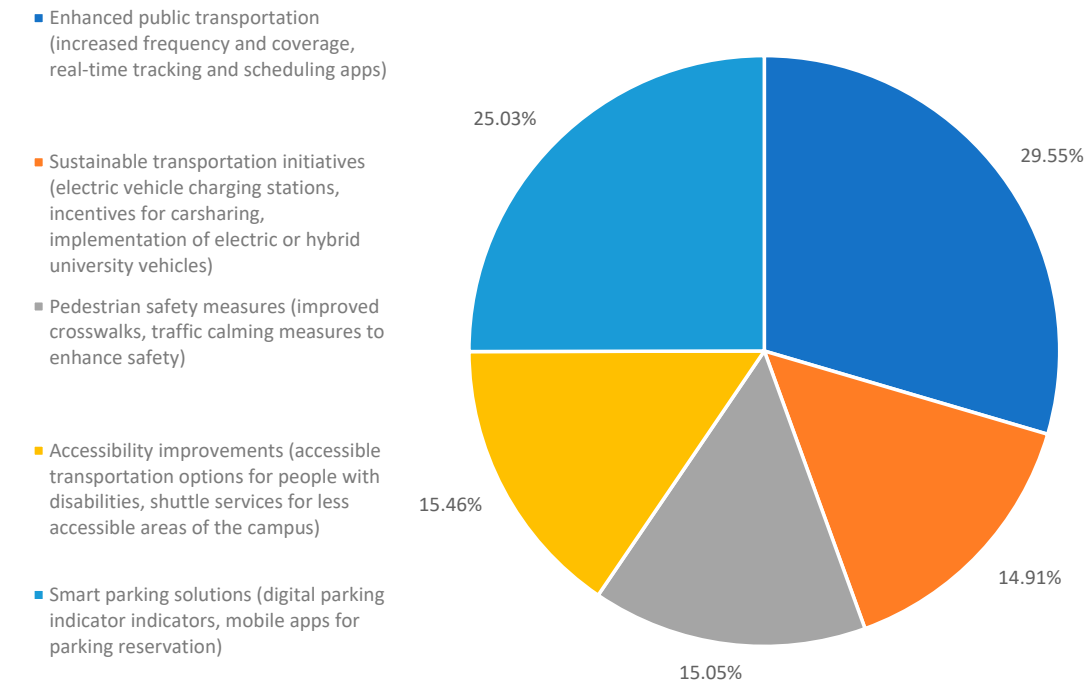


(**a**)



(**b**)

Figure 12. *Cont.*



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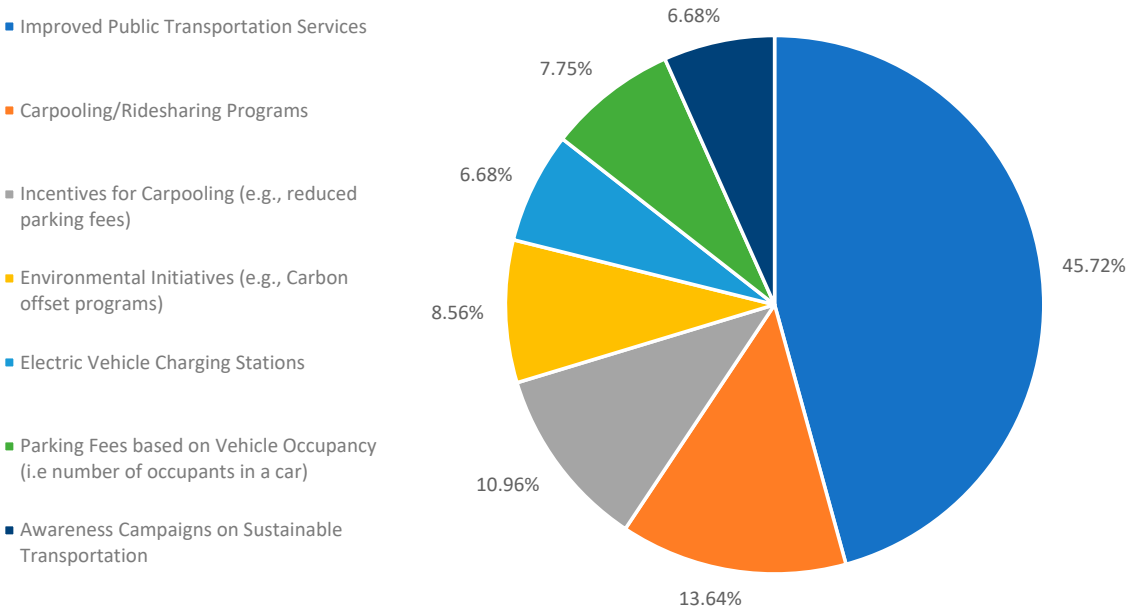

(**d**)

Figure 12. Findings from survey recommendations to be adapted at BAU. (**a**) Strategies to improve campus parking. (**b**) Smart transportation solutions. (**c**) Transportation solutions. (**d**) Initiatives for private car users.

One of the key findings was that the majority of bus-using respondents chose the bus, BAU service, and public transportation, due to the lack of a private vehicle and the cost-effectiveness of the service, as shown in Figure 10. This implies that if they could afford it, they might choose to drive alone. To address this, one recommendation is to launch campaigns highlighting the environmental benefits of bus travel and share testimonials from bus users who choose the bus for environmental reasons.

Interestingly, only a small percentage of BAU bus service, and public-transportation-using respondents (5.5%) mentioned environmental friendliness as a reason for using the bus. To increase this percentage, educational programs about the environmental impact of different transport modes could be introduced across the campuses.

As suggested in Figure 9, a large number of private car users do so, due to inconvenient bus schedules. Therefore, another recommendation is to improve the bus schedule and expand the routes. More frequent buses during peak hours and additional routes covering residential areas could make the bus service more convenient and accessible for private car users. Feedback from current bus users could be used to identify the most beneficial routes and schedules.

The survey, as shown in Figure 12a, also highlighted the need for improvements in parking facilities and services. This could include the addition of sheltering and expansion of capacity, either through partnerships with nearby facilities or the construction of additional spaces. However, with 62.3% of respondents unwilling to pay for a reserved parking spot, the financial feasibility of such improvements may be limited.

The final recommendations are to introduce ride-sharing platforms, as suggested in Figures 12b and 12d, respectively, and efficient parking systems, as the respondents show a preference for in Figures 12b and 12c, respectively. Partnerships with local businesses could promote ride-sharing platforms by offering discounts or incentives for employees who carpool. Efficient parking systems could reduce the number of solo drivers and the demand for parking spaces. Pilot programs could be launched to test the effectiveness of these initiatives.

By implementing these recommendations, we could not only retain the current bus users but also attract new ones, contributing to a more sustainable transport system.

6.5. Comparative Analysis of Scope and Findings

This section presents a comparative analysis of the scope and findings of the current study in relation to other relevant works found in the literature (Table 3). The comparison highlights key similarities and differences in scope, study populations, region, and results, providing context for the contributions of this research.

Table 3. Comparison of this study's scope and findings with previous works.

Reference	Year	Scope	Findings
This Study	2024	Investigation of the travel behavior of travelers to a private university with both a rural and urban campus in Lebanon. Additionally, the examination of how to promote sustainable transportation alternatives to travelers.	Carpooling is the second most common travel mode for BAU students. Most private car-using travelers identified improved public transport as an initiative they would like to implement.
[30]	2024	Investigated Generation Z's travel behavior, focusing on their trip chains and mileage, using Google Maps timeline data for 434 individuals aged 17–24 over 153 days	Men took more daily trips and traveled greater distances than women on both weekdays and weekends. Generation Z individuals with higher financial means made more daily trips, especially on weekends. Gender and financial status significantly influenced daily trips and mileage, with home and workplace or campus locations also impacting travel patterns.
[27]	2023	Investigated how university bus services can promote social equity and sustainability by surveying 303 students at Shahid Bahonar University of Kerman, Iran.	Measures to improve university bus services include upgrading the fleet, enhancing stations, increasing security, and improving pedestrian access. Respondents were highly satisfied with fare levels, bus security, and waiting times. Women reported experiencing discrimination during commutes. Poor-quality bus services lead to more car use and reduced travel sustainability.

Table 3. *Cont.*

Reference	Year	Scope	Findings
[29]	2023	Aimed to link demographic factors, like gender and culture, with tourists' choices of travel companions, destinations, and transportation modes.	International tourists are more eager to travel than Chinese tourists, who prefer traveling with friends. International tourists favor planes and cars, with men more positively inclined towards these modes. Female travelers from mainland China prioritize trains or buses
[2]	2021	Analyzed the travel habits of around 2000 people—students, staff, residents, and visitors—in Sharjah University City, UAE.	Most respondents drive alone. Women generally prefer motorized transport less but use buses significantly more than men. Male respondents use more active transport modes than women.
[26]	2020	Conducted an in-depth study of university students' tour-based travel behavior using panel data from Roma Tre University students.	The preferred mode of transport is private vehicles. 25% of trips were for non-study purposes. This preference may limit the use of public transportation.
[28]	2020	Studied changes in travel behavior due to COVID-19 using an online survey. It gathered 1203 responses globally, focusing on trip purpose, mode choice, distance, and frequency before and during the pandemic.	Changes in trip purpose, mode choice, distance traveled, and trip frequency before and during the pandemic. During the pandemic, shopping trips increased, and there was a significant shift from public to private and non-motorized transport.
[33]	2019	Examine the factors influencing Notre Dame University-Louaize (NDU) students' mode choices using a multinomial logit discrete choice model to analyze their preferences among private cars, shared taxis, taxis, and public buses.	NDU students are primarily influenced by income, travel cost, and travel time. AUB students have resulted in a different mode choice model and higher value of time than NDU students.
[15]	2018	Assessed university students' transportation choices in a developing country across six universities in Danang, Vietnam.	Age, gender, and income significantly affect mode choice. Travel time significantly reduced the preference for walking. Students with motorcycles are open to switching to public transport if it is efficient and reliable.
[20]	2017	Examined how gender affects pro-environmental behavior, suggesting it mainly influences psychological factors shaped by cultural context.	Men showed greater sensitivity to behavior-changing programs, as indicated by higher elasticity values.
[21]	2017	Examined what motivates and hinders cycling among 194 students at a UK urban university.	The main reasons for cycling were enjoyment, fitness, and environmental concerns. Weather and safety issues were the key barriers. Only a few respondents noted the expected decrease in traffic and pollution.
[7]	2016	Employed a web-based travel survey to gather information on students' mode choices across eight distinct universities in China.	Women were more likely to use public transit. Men relied on biking. Longer distances significantly reduced walking potential.
[23]	2016	Surveyed 152 students at the University of Dammam, Saudi Arabia, to explore their views on sustainability.	There was a clear lack of effort towards reaching sustainability goals.
[8]	2015	Examined cultural differences in travel behavior and mode choice at universities in the UK and Ireland.	Women, part-time, and older students favored cars. Male students preferred active transportation. Cyclists and walkers visit the campus more often.
[22]	2014	Investigated factors affecting bicycling and walking at the University of Michigan-Flint.	The importance of bicycle safety for encouraging faculty members to bike. Increased car costs encouraged staff to choose bicycles. Students were more likely to bike when a visible cycling culture was present.
[25]	2014	Compared the transport choices of American University of Beirut (AUB) students with those of the Greater Beirut area's general population.	Raising parking fees and shortening bus travel time with shuttle services or shared taxis could effectively encourage AUB students to switch from cars to public transport.
[9]	2013	Studied student transportation choices at a Canadian university.	Students' daily transportation choices are affected by cost, individual attitudes, and street and sidewalk density.
[19]	2013	Conducted a detailed travel survey at Ohio State University (OSU) to predict transportation preferences for students, faculty, and staff.	Students were more inclined than faculty or staff to use alternative modes like biking and transit for traveling to campus.
[24]	2013	Explored strategies for effective sustainable transportation at the American University of Beirut.	Creating a campus transport service for high-income travelers could be very effective. The study suggested dynamic taxi sharing as an innovative mobility solution.

Table 3. *Cont.*

Reference	Year	Scope	Findings
[11]	2012	Assessed the relationships between transportation to and from the university and various factors, including age, gender, distance, and parking permits	Biking/walking was mostly chosen by women and undergraduates. Private vehicles were used by older students. Increase in carpooling and bus usage for students living far from campus. Having a parking permit increases the likelihood of using a private vehicle.
[18]	2011	Assessed student activity spaces at University of Ulster at Jordanstown in Northern Ireland	Students with cars traveled much longer distances than those without. Low-income students had a longer average activity duration compared to high-income students.
[4]	2011	The study collected information on travel habits, socio-demographic factors, and contextual variables from four major universities in Virginia.	University students' socio-demographic and travel patterns differed from those of the general population. Travel behavior varied between students living on campus versus off campus and between those at urban versus suburban campuses.
[12]	2010	Examined travel behaviors and transportation challenges for university commuters in Barcelona.	The main barriers to switching from cars to non-motorized transport include the following: inadequate infrastructure, limited emphasis on walking and cycling, and extended time required for public transport use.
[13]	2009	Developed a mixed multinomial logit model to analyze mode choice at North Dakota State University.	Higher fuel prices may lead to increased bus ridership. Car owners are more likely to drive, while others use the bus to cut costs.
[10]	2004	Studied at the University of North Carolina-Chapel Hill.	Local topography and sidewalk availability influenced the preference for non-motorized modes in the university community.
[14]	2003	Explored how college campuses promote a shift from cars to sustainable transport on eight campuses across the USA.	Discourage private car commuting. Endorse alternative transportation modes.

7. Conclusions

The primary aim of this study is to examine the travel behaviors at Beirut Arab University's campuses in Beirut and Debbieh, with the objective of enhancing existing policies and strategies to encourage the use of more sustainable modes of transportation. To achieve this objective, a comprehensive travel survey was developed and distributed to gather insights into the preferences and perceptions of travelers regarding transportation issues related to the campus. Data collected from various campus travelers, including students, faculty, and staff, were analyzed to understand their travel behavior, such as their choice of transportation mode, typical travel distance and duration, primary trip purposes, trip frequencies, and how these factors vary between the urban campus situated in Beirut and the rural campus located in Debbieh. Additionally, the survey provided valuable insights into the potential opportunities and obstacles for implementing sustainable transportation initiatives on the campus.

In addition to verifying some well-known campus travel patterns, the data analysis revealed a few intriguing details that university administrators hoping to create a sustainable campus may find useful. The study confirmed that passengers, especially students, prefer driving over other forms of transportation because of the high rate of car availability and the freedom it provides. When examining modal choice, private cars were found to be the most frequently used mode, followed by BAU private bus, public transportation, and car sharing. Most trips were unsurprisingly for educational purposes. Travel modal choice was shown to be significantly dependent on gender, occupation, and the campus being attended. Citizenship was shown to have no effect. Differences in modal choice between male and female students were observed, with men generally less inclined towards non-motorized transportation and utilizing taxis but showing a greater tendency to use motorcycles and driving alone than female students. Unsurprisingly, respondents from the Beirut campus are more likely to rely on active transportation in their trip to campus; less than a quarter of them utilized it which is four times the amount of respondents from the Debbieh campus. Despite Debbieh campus respondents utilizing driving alone more

than Beirut campus respondents, a similar amount used car sharing. The study identified harsh weather conditions and inconvenient bus services as key obstacles to sustainable transportation on campus. Improving the bus service/public transportation, making them more convenient, and providing a ride-sharing platform could attract more travelers from driving alone. However, it is noteworthy that some current bus users cited economic necessity rather than sustainability as their reason for BAU bus service travel.

The findings of this study served as the primary input for the development of a comprehensive travel demand forecasting model currently being developed for BAU. Once completed, this model will be utilized to critically assess every approach and method that is suggested in this study. However, it is important to acknowledge certain limitations of the current study and areas that need further investigation. Firstly, self-report surveys were used, which have the potential to be influenced by social desirability and self-bias. Secondly, even if the response rate was low, more information could be gathered to raise the rate and increase the precision of the travel data that was gathered. Thirdly, the study did not use population synthesis or sample weighing methodologies, which could have affected the representativeness of the sample. Future research could address this by matching the entire university population and utilizing the population synthesis method to increase the sample size.

8. Limitations and Future Works

The findings of this study were instrumental in the development of a comprehensive travel demand forecasting model currently under construction for Beirut Arab University (BAU). Upon completion, this model will be used to critically evaluate all approaches and methods proposed in this study. However, the current study has certain limitations that need to be acknowledged and addressed in future research.

Firstly, the study relied on self-report surveys, which may be susceptible to social desirability and self-bias. Additionally, despite a low response rate, there is potential to improve the precision of the travel data by increasing the response rate and gathering more information. The study also did not utilize population synthesis or sample weighting methodologies, which could have impacted the representativeness of the sample. Future research should address these limitations by employing population synthesis methods and expanding the sample size to enhance the representativeness of the findings.

The study's focus on the BAU population presents limitations regarding the generalizability of the results. The unique characteristics of BAU's population—such as age range, academic backgrounds, and socio-economic status—may not be fully representative of broader populations in other cities or countries. To improve generalizability, future work should validate these findings in other urban settings with diverse populations. Conducting similar studies in various cities worldwide would provide valuable insights for urban planning and transportation policy that are more broadly applicable.

Furthermore, future research should explore how the insights from this study can be integrated into urban planning and transportation policies. Comparative studies examining how preferences and behaviors observed in the BAU population align with those of different demographic groups in various urban environments could inform targeted policy interventions.

Incorporating machine learning techniques into future research could also enhance the analysis of complex data sets and provide deeper insights into travel behaviors and preferences. These models have the potential to offer more accurate predictions and refine policy recommendations. Additionally, revisiting questionnaires to include factors such as economic conditions, attitudes, environmental concerns, and lifestyle choices would contribute to a more comprehensive understanding of transportation behavior. Employing advanced statistical techniques, such as binary or multinomial logistic regression, could further elucidate the factors influencing transportation choices and support the development of more effective policy interventions.

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