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Route Planning for Flexible Bus Services in Regional Cities and Rural Areas: Combining User Preferences with Spatial Analysis

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Abstract: Flexible public transport is defined as a future mobility solution that adapts to user needs and the fluctuating demand patterns that mainly appear in rural areas. However, the temporal variations in traveler preferences for flexible bus services remain largely unexplored in existing research. This constrains the realization of adaptive and customized solutions. Therefore, this study attempts to develop a distinct method for strategic planning of a flexible bus service. To this end, a combinatorial method is undertaken: quantitative social research (questionnaires) and spatial analysis. This combinatorial approach is applied at Korinth and Loutraki in Greece, two significant rural areas neighboring the Athens Metropolitan Area. The results signify that cost and time are the most crucial factors affecting the use of a flexible service. Furthermore, respondents preferred a door-to-door service in the morning and a stop-based service in the afternoon/evening. Concerning route planning, eight routes with different purposes are suggested (e.g., train feeder, touristic, etc.) covering adequately both urban and rural parts of the study area. Notably, the applied methodological approach can be a guideline for planners and policymakers, assisting them in finding effective strategies for introducing flexible public transport in rural areas, especially in contexts where collective transport culture is limited.

Keywords: flexible transport; regional cities; stated preferences; route planning; on-demand transport

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1. Introduction

Traditional collective transport services have so far been unable to support a sustainability-focused transition, especially in areas without a heavy trip demand [1]. Usually, public transportation, when available, often fails to meet the diverse needs of residents due to fixed routes and schedules. A flexible public transport framework is considered a game-changer in car-dependent peri-urban and rural areas. Flexible public transport aims to address this all-increasing demand for mobility by seeking to match the supply of available public transport routes to the fluctuating demand for transport [2]. It is an environmentally friendly solution, operating only when needed, and as a mass transport solution, it is more economical than private transportation. A flexible bus is an accessible mode of transport that adapts to user needs, especially providing a mobility solution to persons with reduced mobility. In other words, flexibility can also mean adaptability, and this adaptability is particularly crucial in areas where public transport infrastructure is underdeveloped, as it provides a cost-effective and responsive alternative to car ownership. A recent report by Frost and Sullivan [3] predicts flexible bus shuttles will account for 50% of the shared mobility market by 2030. They forecast market growth starting from USD 2.8 billion in 2017 to USD 551.61 billion in 2030 and an increase in fleet size from 24,100 units to 5.8 million by the end of 2030.

Demand Responsive Transport, or DRT, is a more specific term that is widely used. DRT "is a user-oriented form of passenger transport characterized by flexible routes and smaller vehicles operating in shared-ride mode between pick-up and drop-off locations, according to passenger needs" [4]. DRT could also be defined as an intermediate form of transport, somewhere between bus and taxi, that covers a broad spectrum of transport services from less formal community transport to area-wide service networks [5]. Furthermore, a DRT service is a public transportation service in which users have to book their trip in advance [6]. Enoch et al. [7] categorized DRT services into four categories: (a) interchange DRT, which provides feeder services to conventional public transport; (b) network DRT, which provides additional services or replaces uneconomic services; (c) destination-specific DRT, that serves particular destinations; and (d) substitute DRT, which replaces, completely or substantially, conventional bus services.

In recent years, various cities have experimented with flexible bus services. Helsinki's 'Kutsuplus' pilot from 2012–2015 showcased an automated DRT system integrating taxis and ride-sharing with features like SMS hailing and virtual bus stops. Despite reaching 100,000 annual trips, it ended due to capacity and vehicle availability issues [8]. Conversely, Kansas's DRT shuttle bus pilot in the US anticipated 200 trips daily but achieved only 597 in six months, making each trip cost nearly USD 1000 [9]. The FLEX system in Santa Clara Valley in 2016 underscored the significance of DRT algorithms. Although improvements were made, the service ceased after six months due to challenges like vehicle availability, geographic limits, and unionized staffing issues [10]. The list of DRT service implementations is ever-growing, and experience from other projects directs the research focus of investigating the launch of a DRT service toward a thorough understanding of the characteristics of the environment, the users, and the DRT system itself before proceeding to design a service that will be successful.

Certain relevant studies encountered in the existing literature have demonstrated the following insights: Initially, Davison et al. [11] determined that the most significant factors for employing an on-demand system are the availability of vehicles and the number of seats, namely functional characteristics. Koning and Grippenkoven [12] revealed that the operational conditions and efficiency of the service constitute the most crucial factors for adopting such a service. Research conducted by Torrisi et al. [13] elucidated that the significant determinants for selecting an on-demand service are affordable pricing, i.e., cost, high frequencies, and adequate information. On the same page, the work of Campisi et al. [14] concluded that the most pivotal factors influencing the choice of such a service in terms of its operation are the accuracy of routes and the avoidance of overcrowding within the vehicle. Bronsvoort et al. [15] demonstrated that cost, access/egress times, and in-vehicle times play a significant role in individuals' preferences for choosing flexible transport services. Regarding other factors, parking difficulty and non-possession of private transport modes were proven critical too. The scoping literature review by Schasche et al. [16] demonstrated that the primary usage determinants include waiting time and stop location, cost, and frequency of routes, while also underscoring adequate information, reservation systems, and issues related to comfortable access to vehicles of such a service.

What is more, age and gender are proven to be critical in choosing flexible transport services [17]. According to Terry and Bachman [18], women are more open to using flexible transport services, while the literature holds different perspectives on the matter of age. To be more precise, Anburuvel et al. [17] argued that younger people are more likely to use flexible bus services, but Frei et al. [19] and Knierim and Schluter [20] demonstrated that the elderly (mainly in rural areas) are more willing to use relevant schemes. Considering the spatial dimension, the study of Ryley et al. [21] demonstrated that trips to health facilities, shopping, and group leisure activities were found to have the highest potential to convert to

DRT. Wang et al. [22] used a multi-level area-based analysis of data in Greater Manchester, England. They revealed that the demand for DRT services is higher in areas with low car ownership, low population density, and high levels of social deprivation in terms of income, employment, education, housing and services, health and disability, and urban life quality.

Nonetheless, to effectively serve the users, it is essential to formulate readable and attractive routes as well as to deploy efficient passenger collection points that will facilitate public access to the on-demand service. A door-to-door service may minimize access times to and from passenger collection points, but it leads to greater in-vehicle travel times [23–25]. Consequently, the bus makes several deviations to meet high demand needs. To this end, spatiotemporal variations in demand should be adequately forecasted before designing such a "realistic flexible" service [26]. For the literature gap, existing research focuses on optimization techniques [6,27,28], but a holistic planning approach incorporating demand modeling, conceptual planning, and spatial analysis tools is still missing in the scientific literature. New approaches should ensure a successful demand-responsive system considering all the previously mentioned factors and good/bad practices.

The objective of this study is to develop and apply an alternative methodology for strategic route planning of flexible bus services in rural or peri-urban areas. It focuses on local communities who are unfamiliar with on-demand transport, aiming to understand their attitudes and preferences and pre-estimate their intention to use this new service. Through a data-driven approach, it configures important service planning factors like stop spacing and line spacing. Last, this study aspires to integrate an evaluation framework to prioritize routes, providing valuable input to transport operators who may be unable to operate all routes due to budget or other constraints. The methodological framework was initially implemented in the regional city of Corinth, Greece, and its peri-urban area. Located 83 km from Athens, Corinth has a population of 56,432 residents, according to the latest census.

The remainder of the paper is structured as follows: Section 2 presents the combinatorial method, especially focusing on the stated preference survey, spatial analysis, and multicriteria decision-making process. Next, Section 3 provides the results, illustrating how this method is applied to the study area. Following, Section 4 reflects the discussion on findings, limitations, contribution, and further research recommendations. Finally, Section 5 draws solid conclusions.

2. Method

The methodological framework followed consists of three distinct stages that utilize novel or traditional tools and techniques. Initially, the first stage concentrates on social research, and particularly, it includes a stated preferences experiment (Survey). This technique aspires to identify the actual factors influencing the willingness to adopt flexible route services in an urban–rural context with high car dependency and poor public transport. Next, the second stage employs spatial analysis techniques to formulate flexible routes (Planning). Finally, the last stage involves multicriteria analysis (i.e., REGIME) to evaluate and rank the proposed routes in terms of implementation urgency (Assessment). All these three stages comprise the SPA framework, meaning Survey, Planning, and Assessment (see Figure 1).

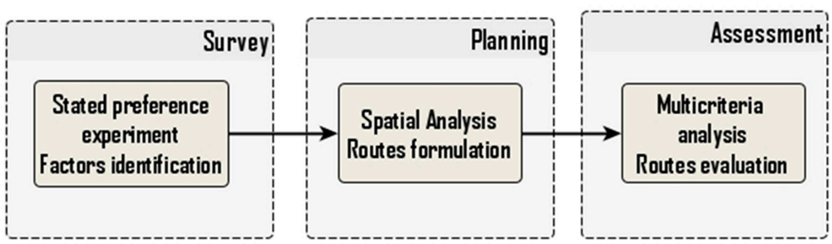


Figure 1. General flow diagram of the SPA method.

2.1. Stated Preference Experiment and Demand Modeling

The first step of the overall approach investigates the future demand for such a service by conducting a stated preferences experiment [29]. The willingness to use a flexible bus service is described by a variable in binary format. Stated preference experiments contain hypothetical (or imaginary) scenarios related to this future service. The main steps for designing a stated preferences survey are (1) definition of the dependent and independent variables, (2) selection of the measurement unit and levels of independent variables, (3) mathematical specification of the utility function and unknown parameters, (4) design of scenarios using fractional factorial design or efficient design, (5) conversion of scenarios into questions and formulation of the questionnaire form, (6) selection of the calculation method and data organization method, (7) conducting a pilot study and developing a questionnaire distribution strategy, and (8) data analysis and computation of the statistical models [30,31].

The variables and their respective levels were defined based on a review of previous relevant studies, as they were mentioned in the Introduction. Of course, in this process, the hypotheses that the research team aimed to test were taken into consideration. First, the respondent will have to choose between 1 and 0. It is a binary and stochastic variable. The value of 1 is associated with the willingness of one individual to use the flexible bus service, while the 0 value refers to the chance of not changing his/her present travel behavior. This means the use of any other mode that is available today in the study area. The service costs are set based on the hypothesis that pricing for flexible mobility services should fall between the cost of a public transport ticket and the operational cost of a personal vehicle, ranging from 1.5 to 4.5 euros [25,26]. Travel time is categorized into in-vehicle, waiting, and walking durations. Analyzing these components offers a deeper understanding of the desired flexibility of the new service, whether it is stop-based or door-to-door. The walking time from/to the pick-up/drop-off point can be 5, 10, and 15 min, while the waiting time cannot exceed 15 min in the scenarios included in the stated preferences survey. Three levels are also determined in the in-vehicle time variable, i.e., 10, 20, and 30 min. Last, a set of individual-specific or socio-demographic variables are considered, namely age, gender, income, education, car ownership, and bicycle ownership. Table 1 presents the main explanatory variables.

Table 1. Independent variables and variable levels.

Independent Variables	Variable Type	No. Levels	Levels
1. Context variable			
Peak hour	dummy	2	0: off-peak hour; 1: peak hour
Period	dummy	2	0: evening or midnight; 1: morning or midday
2. Trip variables			
Service cost	continuous	3	1: 1.5 euros; 2: 3.0 euros; 3: 4.5 euros
In-vehicle time	continuous	3	1: 10 min; 2: 20 min; 3: 30 min
Waiting time	continuous	3	1: 2 min; 2: 6 min; 3: 10 min
Walking time	continuous	3	1: 5 min; 2: 10 min; 3: 15 min
3. Individual-specific variables			
Age group	categorical	5	0: 1: 18–29 years old; 2: 31–39 years old; 3: 41–49 years old; 4: 51–64 years old; 5: ≥65 years old
Gender	dummy	2	0: female; 1: male
Income group	categorical	6	0: no income; 1: ≤750 euros/month; 2: 751–1500 euros/month; 3: 1501–2500 euros/month; 4: >2500 euros/month
Education	categorical	5	0: no education; 1: primary school; 2: secondary school or high school; 3: university; 4: master or PhD
Car-ownership	dummy	2	0: no car; 1: yes car
Bicycle-ownership	dummy	2	0: no bicycle; 1: yes bicycle

As has been mentioned, the most noteworthy advancement is the incorporation of two context variables that account for different times of the day. These context variables introduce interaction effects with the previously presented explanatory variables, implying that aspects such as travel time or cost might have varied significance based on the time context. This consideration aids in devising planning solutions that more accurately align with time-specific demands and preferences, thereby enhancing the likelihood of the service being utilized. The inaugural context variable pinpoints the peak travel hour. This variable is binary: a value of 0 signifies off-peak times, while 1 indicates peak travel hours. To further categorize the peak periods, a secondary variable named period discerns whether the time is between afternoon and midnight or between morning and midday. This creates a set of 2 × 2 combinations splitting the day into four periods, i.e., 07:00–09:59 (morning/midday peak), 10:00–13:59 (morning/midday off-peak), 14:00–16:59 (afternoon/evening/midnight peak), and 17:00–23:59 (afternoon/evening/midnight off-peak). The specification of time slots was based on travel surveys and traffic measurements conducted in the study area. Based on the above considerations, the model utility function can be defined. In essence, Equation (1) is the mathematical transformation of Table 1.

$$\begin{aligned}\log\left(\frac{P(V_{i,j})}{1-P(V_{i,j})}\right) &= \beta_0 + \beta_{price} * price_i + \beta_{peak} * peak_i * \beta_{pr} * pr_i \\ &* (\beta_{trav} * trav_i + \beta_{wait} * wait_i + \beta_{walk} * walk_i) \\ &+ (\beta_{age} * age_j + \beta_{gen} * gen_j + \beta_{\iota nc} * inc_j + \beta_{edu} * edu_j + \beta_{cwn} \\ &* cwn_j + \beta_{bwn} * bwn_j) + \varepsilon_{i,j}\end{aligned} \tag{1}$$

where

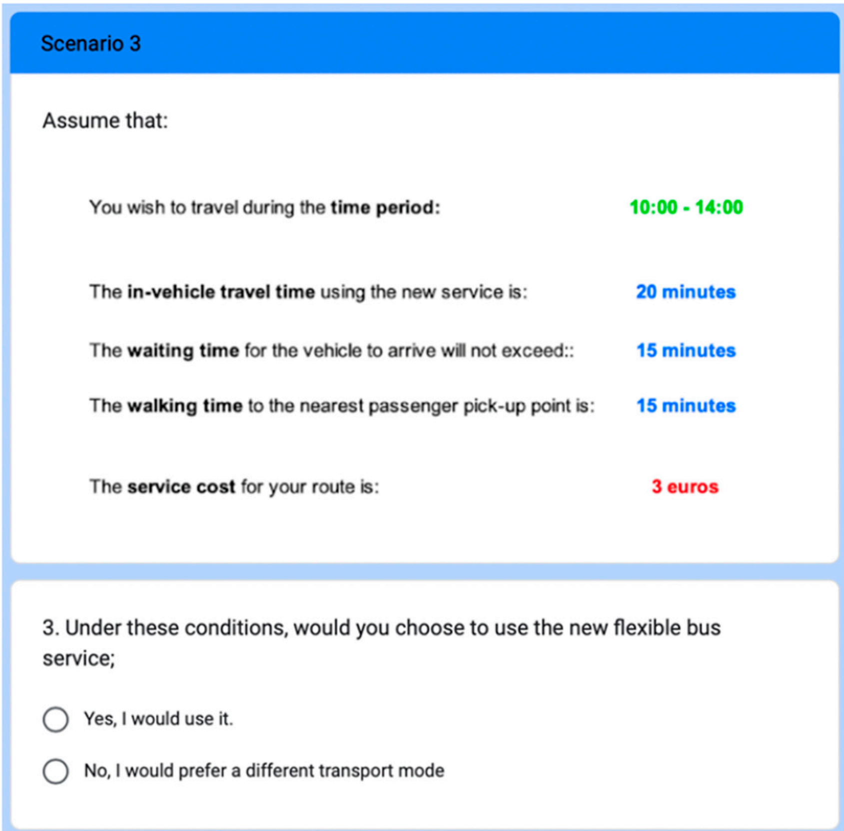
$P(V_{i,j})$: the probability of using the on-demand bus service by individual j in scenario i;
V_i: systematic utility of using j on-demand bus service by individual j in the scenario i;
β_0 : intercept parameter of the utility function;
$\beta_{price}sub - peak, \beta_{peak}, \ldots, \beta_{bwn}$: model beta parameters;
$price_i$: service cost in euros in scenario i;
$peak_i$: 1, if peak hour period in scenario i;
pr_i: 1, if morning or midday period in scenario i;
$trav_i$: in-vehicle travel time in minutes in scenario i;
$wait_i$: waiting time in minutes in scenario i;
$walk_i$: walking time in minutes in scenario i;
age_j: age group of individual j;
gen_j: 1, if individual j is male;
inc_j: income group of individual j;
edu_j: education level of individual j;
cwn_j: 1, if individual j owns at least one car;
bwn_j: 1, if individual j owns at least one bicycle.

Considering all the variables, there are 2 × 2 × 3 × 3 × 3 × 3 = 324 combinations. The evaluation of 324 scenarios by a single respondent is surely not possible. That is why the survey is constructed based on the fractional factorial design method, which ensures zero correlations among the defined explanatory variables while eliminating the output scenarios. However, this design does not minimize correlations among interaction effects of variables unless these effects are specifically included in the utility function. For instance, in this survey, the interaction effect between contexts and trip variables should not be colinear with the other model variables. In other words, respondents should balance their choices considering all the different contexts (i.e., period of the day) that can be formulated. The fractional factorial design is based on an orthogonal table, which in this case has 36 scenarios in total. Four blocks of questions are constructed so that each respondent will evaluate only nine scenarios.

The following notice is added before the scenarios' presentation; it gives the main hypotheses that should be considered by the respondent before answering: "*In the upcoming experiment, imagine that you need to travel a distance of 12 km on an average day. By car, the estimated travel time is 18 min, assuming no traffic congestion. This estimation does not account for the time it might take to find parking. On foot, covering this distance would take approximately*

144 min (or 2 h and 22 min). If you were to cycle, it would take about 48 min. Additionally, there is a new on-demand service available. Through a user-friendly app, you can call a bus to pick you up at a designated passenger collection point".

In the subsequent phase of this procedure, scenarios are translated into relevant question sets. As an illustration, Figure 2 presents a typical scenario found in the survey. To offer a succinct overview of the conditions presented in each scenario, color coding and bolded key terms are employed. Questions about socio-demographic characteristics were positioned at the end of the survey. The form also captures the current travel patterns of respondents, allowing for a comparison with their expressed preferences. The survey was digitized using Google Forms, accompanied by a comprehensive guide and overview on the introductory page. Before participating, every respondent gave informed consent. Despite the anonymity of responses, participants had the option to bypass questions related to socio-demographic information.


Scenario 3

Assume that:

You wish to travel during the **time period:** 10:00 - 14:00

The **in-vehicle travel time** using the new service is: 20 minutes

The **waiting time** for the vehicle to arrive will not exceed:: 15 minutes

The **walking time** to the nearest passenger pick-up point is: 15 minutes

The **service cost** for your route is: 3 euros

3. Under these conditions, would you choose to use the new flexible bus service;

Yes, I would use it.

No, I would prefer a different transport mode

Figure 2. Sample scenario.

The survey was primarily shared through social media and emails targeting residents of Corinth and Loutraki, Greece. These individuals represent potential future users of flexible public transport services, making it essential to carefully consider their needs. However, individual needs can vary significantly. Thus, efforts were made to ensure the survey represented diverse social groups, with special emphasis on capturing varying employment statuses and age groups, both of which greatly influence preferences in the end. In other words, in this approach, the primary focus was not on sample size but rather on capturing a diverse range of opinions from the study area. The data collection process spanned from June to September 2022. A block randomization algorithm was employed to distribute the various blocks of scenarios using a single link. This ensures that the same number of responses will be collected per block. It ensures zero correlations among the selected independent variables in the final dataset, as the survey was designed in the first planes. The estimation of unknown parameters is achieved by applying the maximum likelihood estimation (MLE) method.

2.2. Spatial Analysis and Conceptual Planning

This stage entails all the activities related to strategic planning of the routes. Notably, it contributes to the formulation of different types of routes in the study area. Figure 3 illustrates the basic steps needed to accomplish this planning stage. The main spatial analysis technique involves an adjusted shortest-path algorithm developed to translate the conceptual routes into real ones.

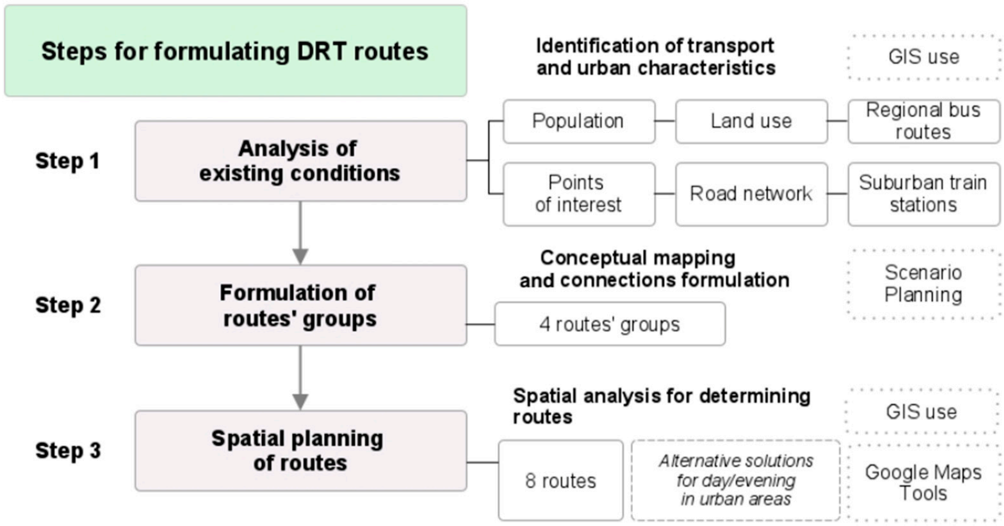


Figure 3. Flow diagram of route planning.

Step 1 involves the analysis of the existing conditions of the study area through the examination of its urban and transport characteristics. Specific elements are documented: The road network includes data about the hierarchy of the road network, road pavement width, and traffic direction of the roads. Population and density are examined in each settlement within the study area. Points of interest encompass archaeological sites, beaches, and others. Routes and stops of public transportation include railway lines, regional bus routes, and local (urban) bus services. Land uses are sports facilities, commercial and recreational areas, cultural sites, educational institutions, health facilities, industrial zones, public services, public spaces, places of worship, tourism-related areas, and other land use categories (i.e., clusters for commercial activities).

In step 2, the groups of routes are defined, describing various objectives and characteristics. Routes are divided into four groups. The first group addresses feeding services to the suburban railway (RG1). The next two groups concern the connection of settlements, specifically the connection between settlements and urban centers (RG2) and the connection of urban centers with each other (RG3). The fourth group is destined to serve the touristic destinations within the study area (RG4). These groups are characterized by different levels of urbanization and distances to be covered. The following conceptual figure (see Figure 4) illustrates the relationship between urbanization levels and route distances of each group.

What is more, some illustrative cases depicting conceptual connections per route group are presented in Figure 5. More specifically, in RG1, a direct connection between settlements and urban centers with suburban train stations is suggested. In the same line, RG2 resembles direct connections. Moving to RG3, it is essential to note that two types of connections are noticed. The first one addresses the connection of urban centers with each other, and the second one relates to the connection of urban centers with suburban train stations and regional bus stations. Finally, RG4 emphasizes touristic destinations. Interestingly, this type of route group connects points of interest with settlements, urban centers, and public transport stations as well.

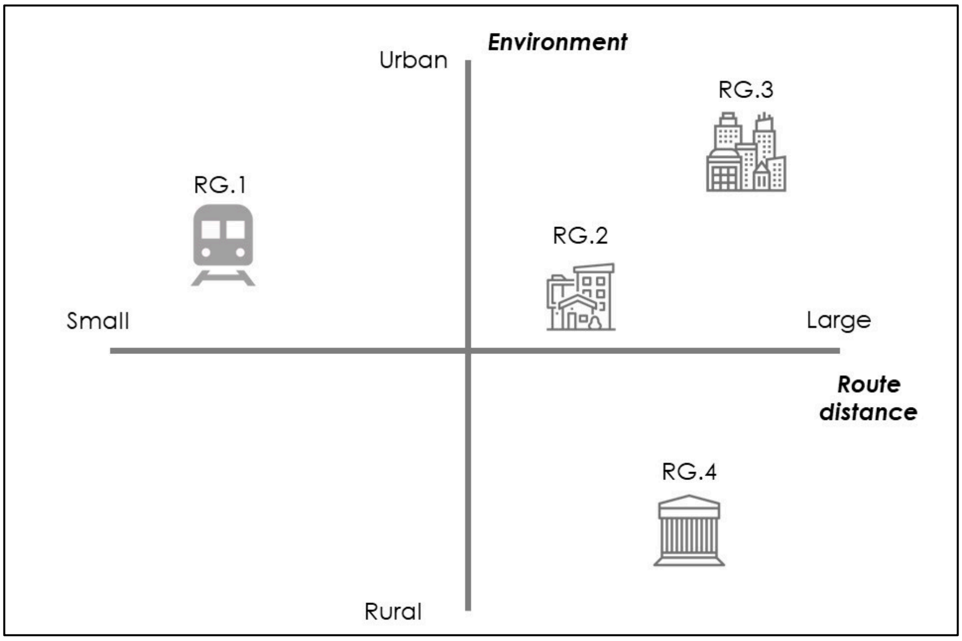


Figure 4. Relationship between urbanization level and route distance.

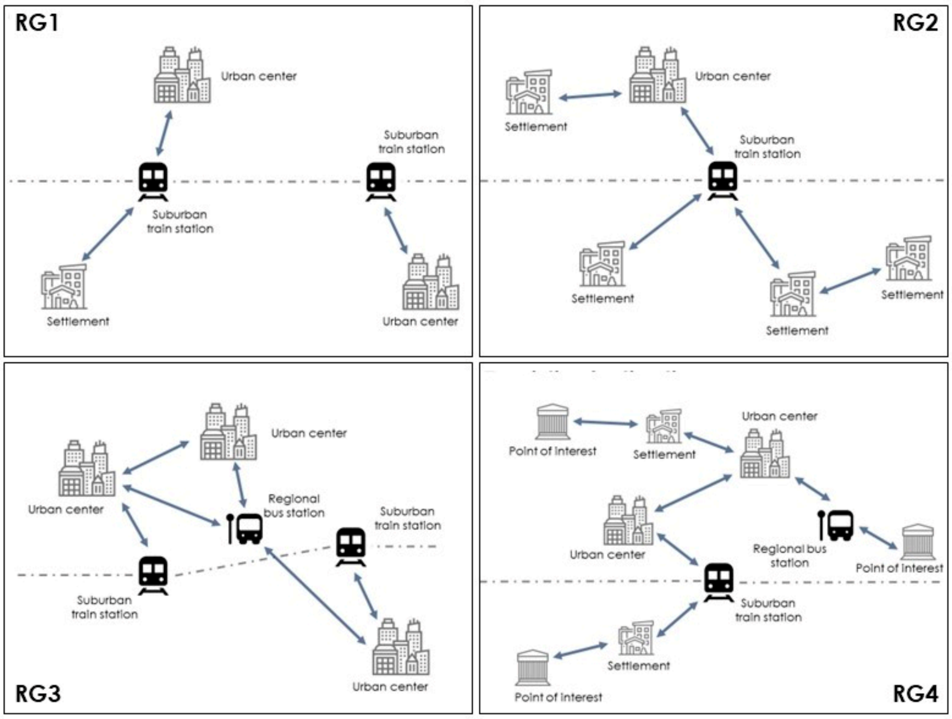


Figure 5. Conceptual connections of routes per group.

Step 3 involves the actual spatial determination of the routes, where "conceptual connections become reality". In this context, only town centers with more than 2000 residents and settlements with more than 1000 residents are considered further. Especially concerning the main urban centers, they are linked with settlements that can be encountered within a 10 km radius (Euclidean distance) from the central area of each town. The shortest paths connecting these points are determined; the Dijkstra algorithm is applied. Not all points are connected though, as it would be impractical and unrealistic for the flexible bus system. When it comes to routes passing through the main town, the methodology slightly changes. The routes follow an adjusted shortest route based on the number of non-residential land uses (i.e., demand/attraction points), weighted by the road width, which ensures the feasibility of the flexible bus operation [32,33]. Advanced network analysis tools are utilized. Finally, criteria related to the walking distance from the nearest passenger collection point are established, namely 200, 300, 400, and 500 m. This condition gives a range of four-stop spacing scenarios referring to spatial variations of collection points. This option is followed only in areas with more than one demand/attraction point. In the small settlements of rural areas, only one scenario is developed. Specifically, one passenger collection point is established in each central square of rural settlements.

2.3. Assessment and Routes' Ranking

In the final stage of the SPA method, the evaluation of the routes is carried out via the multi-criteria analysis REGIME. More specifically, during this stage, the routes are ranked based on significance and feasibility.

Multicriteria analysis (MCA) is a remarkable tool, allowing the analysis and evaluation of multiple aspects of a problem that could be considered in the decision-making process. It is used in various cases, including classification, ranking, and evaluation of different alternative proposals or scenarios [34]. The fundamental components of the multi-criteria analysis process are the following: (a) alternative solutions; (b) criteria; and (c) weights related to these criteria [35]. Multi-criteria techniques are used in many transportation policy studies to address complex decision-making problems where policymakers face multiple and sometimes conflicting criteria [36]. An interesting paradigm of using MCA in the planning process is the development of the Bicycle Metropolitan Network in Athens [37]. Overall, MCA can easily be combined with other participatory methods, creating a more flexible evaluation framework that facilitates the involvement of a broad range of stakeholders during the assessment process [38].

REGIME is a distinct process of multi-criteria evaluation that accepts both qualitative and quantitative data [39]. It is a qualitative method of multiple attributes that solves the problem based on a pairwise comparison of all alternatives. The application of this method relies on two types of input data: the evaluation (impact) matrix and a set of policy weights [40].

At this point, the evaluation criteria for the routes and the evaluation process should be chosen. The criteria are drawn from the relevant literature and are divided into three main categories, i.e., urban planning, demographics, and transportation [12,15,33,41]. The criteria are also aligned with the strategic objectives of this service, established at the start of the planning process. Firstly, the urban planning criteria include the following: 1. Route significance; 2. Land uses along the route; and 3. Land use mix. Next, the demographic category encompasses one criterion, that of 4. Served population. Lastly, category 3 represents the transportation criteria, which are as follows: 5. Estimated route travel time; 6. Route length; 7. Road network hierarchy discontinuity; and 8. Feeder service of suburban railway stations. These criteria cover a wide range of dimensions and factors related to the operation of a flexible bus service [22,42]. They can be found along with their description in Table 2.

Table 2. Criteria, descriptions, and values/measurements units.

Group	Criteria	Description	Values/ Measurement Unit	Direction
Urban Planning	Route Significance	The urban significance of the route depends on the points it connects.	Low, Medium, High	Positive
	Land Uses along the Route	The number of non-residential land uses encountered along the route	Number of different land uses	Positive

Table 2. *Cont.*

Group	Criteria	Description	Values/ Measurement Unit	Direction
Urban Planning	Land Use Mix	The entropy index of non-residential land uses encountered along the route	Plain	Positive
Demographics	Served Population	The population served by the route, depending on the urban centers or settlements it connects	Number of individuals	Positive
Transport	Estimated Travel Time	The estimated travel time resulting from using Google Maps	Minutes	Negative
	Route Length	The actual length of the route	Kilometers	Negative
	Road Network Hierarchy Discontinuity	The instances along the route where the hierarchy changes	Plain	Negative
	Feeder service of suburban railway stations	The suburban railway stations the route passes through	Number of suburban railway stations	Positive

After defining the criteria, the REGIME evaluation takes place. The method is chosen to be applied four times due to validation and clarity reasons, i.e., (1) non-weighted evaluation, (2) demographics-urban planning-transportation, (3) urban planning-demographics-transportation, and (4) transportation-urban planning-demographics.

3. Results

As has been mentioned, the SPA method was firstly applied in the peri-urban area of Corinth, Greece. It acts as a study case aiming to become a good practice in public transport planning. Its high level of car dependency and the poor existing conditions related to urban or rural public transport warranted this decision.

3.1. Demand Modeling Outcomes

In a structured survey conducted, 181 respondents furnished valuable data that served as the foundational inputs for network planning. Women constituted 53.04% of this group, with a significant portion aged between 18 and 29 years. Approximately 50.83% earned between 1500 and 2500 euros monthly. Regarding the educational levels, it was revealed that a substantial number held bachelor's degrees or higher. 91.71% of the sample owns at least one car. ANOVA results indicated age and gender's significant influence on choices at a 95% confidence level, with education also playing a role but correlating with age. Travel preferences are related to the travel distance, as expected: most (i.e., 74.03%) preferred walking for short trips up to 500 m, but as distances reached 5 km, the share of public transport peaked at 14.92%. For distances over 1 km, more than half relied on private cars, with 14.92% being car passengers for 10 km journeys. Motorcycle usage hovered around 8% for 1 to 2.5 km trips, while bicycle and taxi usage remained below 5% and 4%, respectively.

The subsequent phase involves determining the binary logistic regression model, with results shown in Appendix A. Predictably, the coefficients of walking (+0.086 utils/min), waiting (−0.097 utils/min), and in-vehicle time (−0.067 utils/min) emerged as vital parameters, each holding statistical significance at a 95% confidence interval. All of them are associated with a negative value, except the coefficient for walking time, which is positive. This suggests a propensity for travelers to walk longer during evening off-peak hours, as all context variables are equal to zero. Concurrently, the service price is another significant factor at the same confidence interval, possessing a negative coefficient, i.e., −0.344 utils/euro. Delving into the interaction effects, variances in coefficients across time intervals are evident. Specifically, preferences for walking and in-vehicle time seem to vary depending on the time of day, with walking being more favored during the morning

(−0.291 utils/min) and afternoon peak hours (−0.143 utils/min) than nighttime. However, the influence of waiting time on the utility of the new flexible bus service remains relatively consistent across tested intervals. Concerning gender distinctions, men displayed a greater reluctance to adopt the new service than women, as indicated by a negative beta coefficient. Moreover, the age demographic of 18–29 years showed limited interest in utilizing the new flexible bus service. To achieve a clearer interpretation of the model's outcomes, the value of time (VoT) is appraised across various timeframes [43]. The VoT is the ratio between the coefficient of cost and time. The results are presented in Table 3.

Table 3. The VoT per period.

	Morning Peak	Midday Off-Peak	Afternoon Peak	Evening Off-Peak
in-vehicle time	EUR −4.69	EUR 5.13	EUR 3.10	EUR 11.77
waiting time	EUR −7.21	EUR 7.00	EUR 11.37	EUR 16.86
walking time	EUR 35.77	EUR 8.52	EUR 9.94	EUR −14.96
Total	EUR 23.86	EUR 20.65	EUR 24.41	EUR 13.67

During morning peak hours, there is an evident inclination among respondents to exchange 35 euros to save one hour of walking. Contrastingly, during the afternoon peak, long waiting and in-vehicle time due to detours significantly impede the attractiveness of this new mode, leading to a generally diminished propensity to use the service. The total VoT during the morning peak is around 23.86 euros/h. This figure experiences a decline during the midday off-peak, settling at 20.65 euros/h. Specific to walking and in-vehicle durations, VoT values are 8.52 and 5.13 euros/h, respectively. As we progress, during midday off-peak and afternoon peak hours, the negative coefficients associated with all the time variables suggest an increasing disutility with each added minute of travel. This value culminates during the afternoon peak when users demonstrate a willingness to exchange approximately 11.37 euros for a reduced hour of waiting. The afternoon peak is also associated with the minimum value of in-vehicle time VoT at 3.10 euros/h. Yet, come evening off-peak hours, this situation is completely reversed. Respondents are willing to walk more (−14.96 euros/h) than waiting (+16.86 euros/h) or traveling more (+11.77 euros/h). This means that a 15-min reduction in waiting time due to service flexibility saves each user 0.60 euros during the morning peak hours. Similarly, a 15-min reduction in walking time from a door-to-door option saves each user 3.74 euros during the evening off-peak hours.

Figure 6 illustrates that the likelihood of adopting the new flexible bus service diminishes swiftly with prolonged walking durations to/from the collection point. It provides the model predictions, yet their accuracy cannot be assessed a priori. In addition, the service does not exist today.

3.2. Route Planning Outcomes

This sub-section presents the results related to the spatial planning method (analysis and planning). First and foremost, a fundamental step in this stage is the analysis of existing conditions. Based on data deriving from the Hellenic Statistical Authority related to the 2011 census, it is evident that there are a total of 83 settlements within the study area. The settlement with the largest population is Corinth, with 30,176 residents, resembling the main urban center of the area, followed by Loutraki with 11,564 residents, Agioi Theodoroi with 4643 residents, and Lechaio with 2643 residents. Furthermore, the average population per settlement stands at 957 residents. Shifting the interest toward road network hierarchy, the regional road network can be classified into the following categories: (a) Primary National Road Network (with a total length of 131.2 km), (b) Secondary National Road Network (with a total length of 185.8 km), (c) Tertiary National Road Network (with a total length of 38.5 km), (d) Main Provincial Road Network (with a total length of 137.0 km), and (e) Local Provincial Road Network (with a total length of 464.3 km). Within the urban road network of Corinth, the following road categories can be encountered, each with its respective length: a primary road network spanning 10.40 km, a secondary road network covering 3.41 km, collector roads with a total length of 3.41 km, pedestrian streets extending over 0.81 km, and local roads with a combined length of 58.35 km. Figure 7a illustrates the population distribution per settlement and the road network hierarchy (both municipal and urban in Corinth).

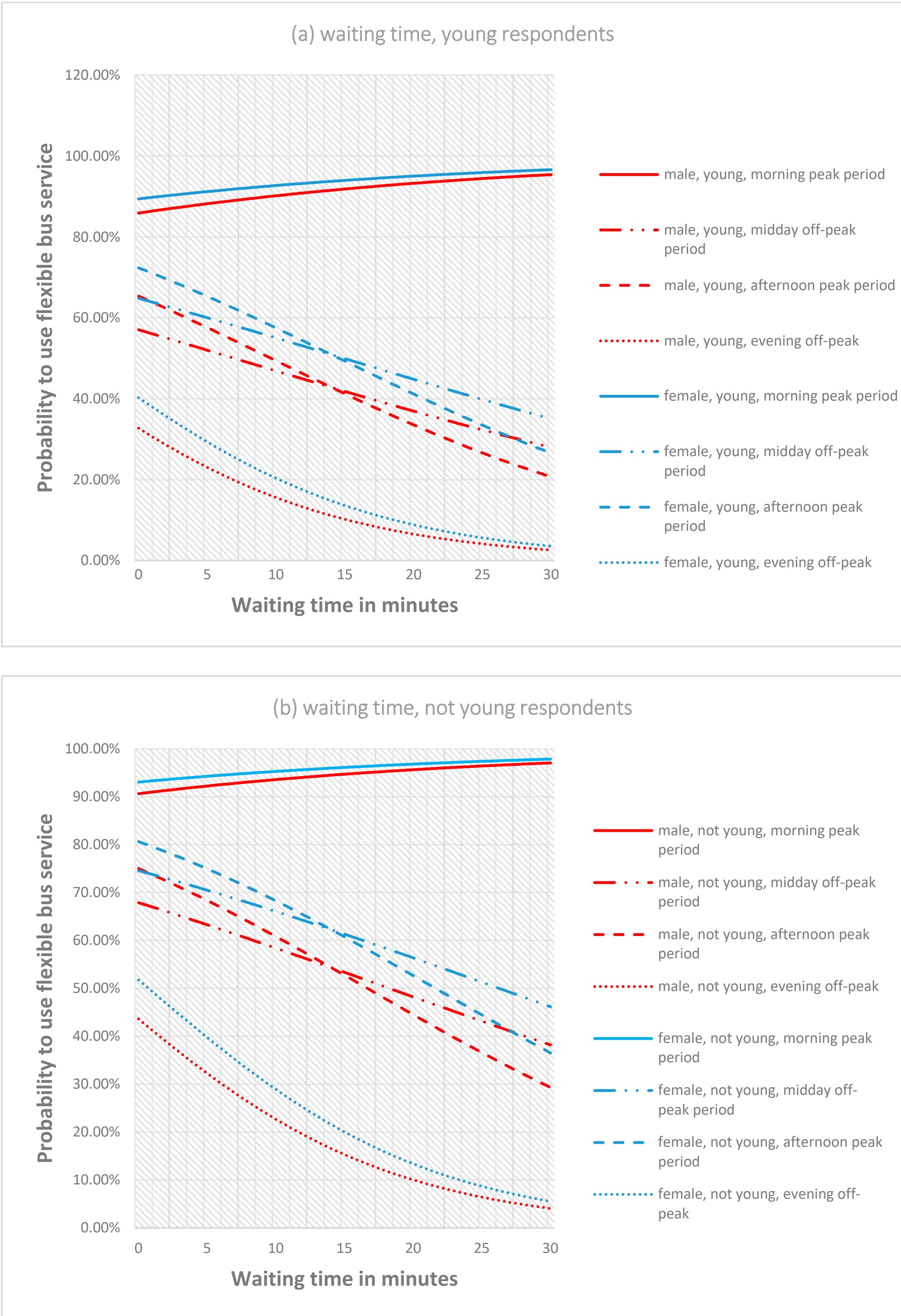
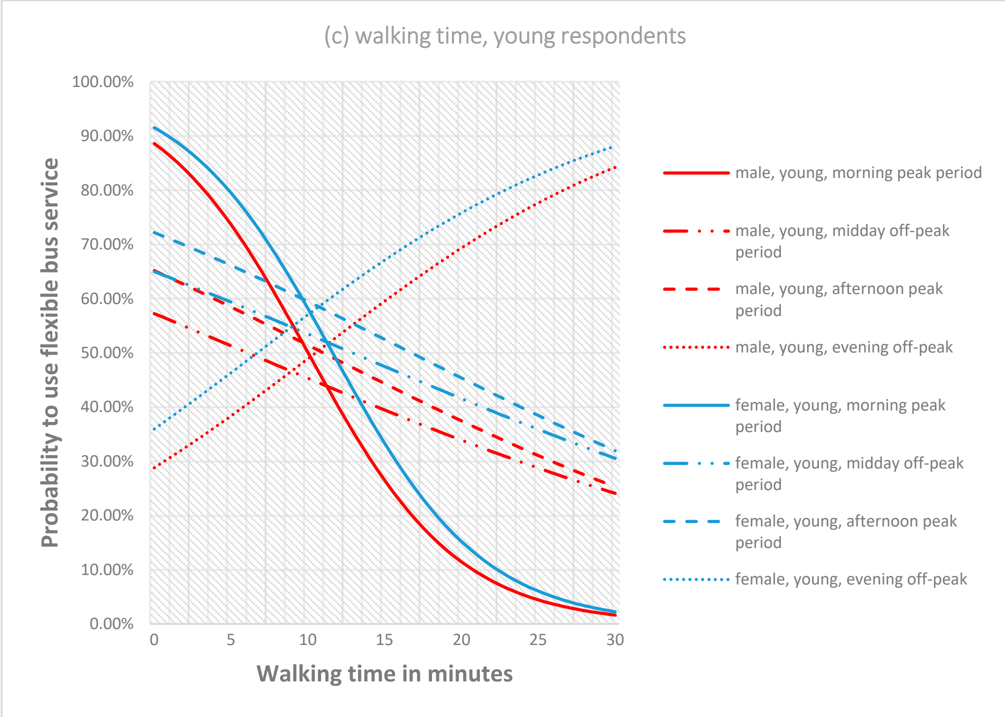


Figure 6. *Cont.*



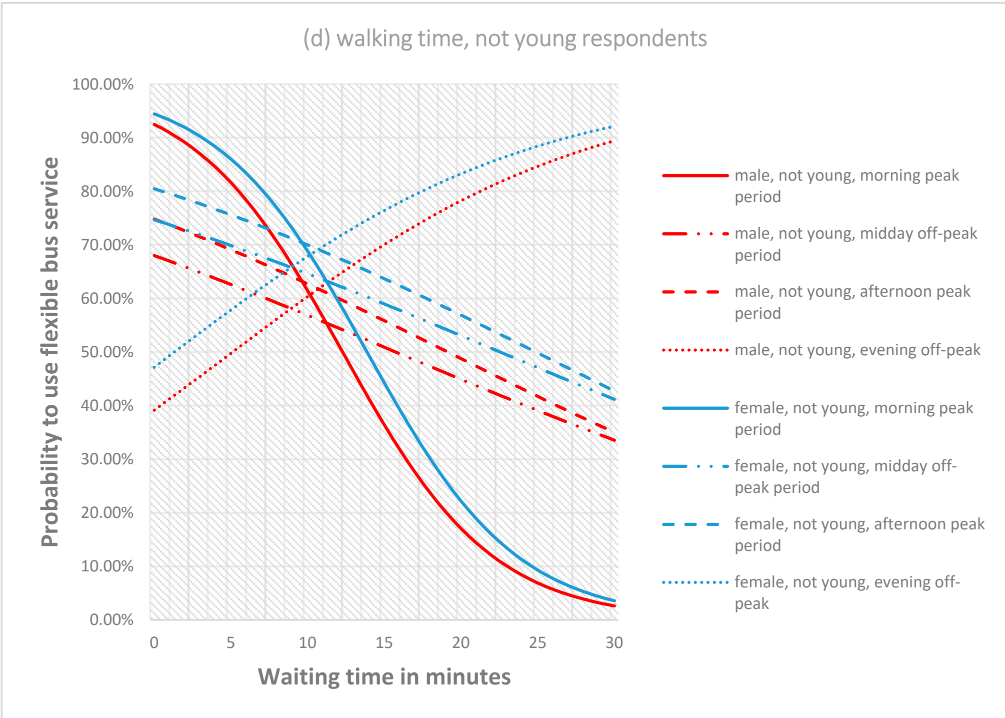
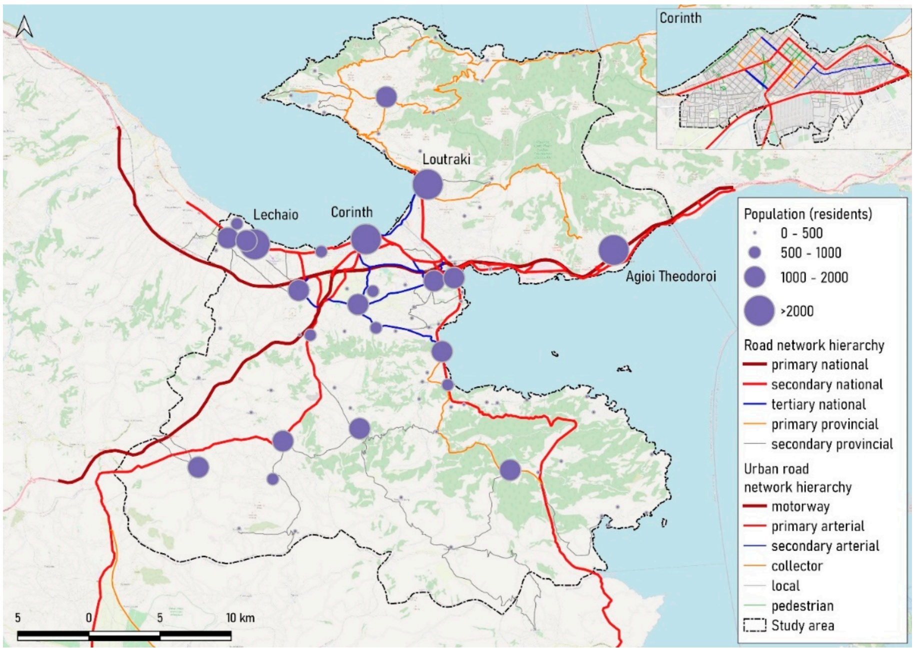
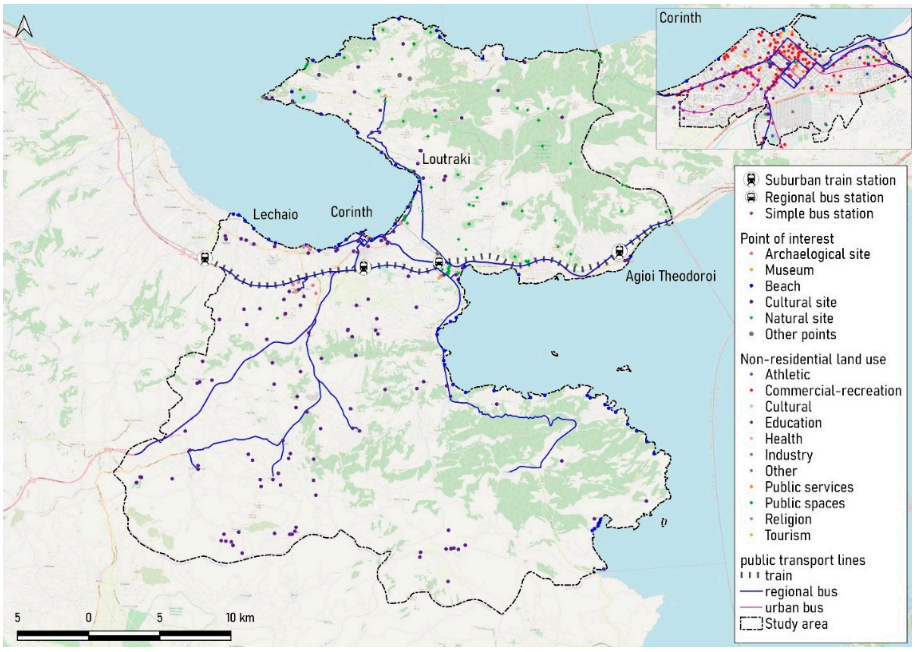


Figure 6. Fluctuation of probability to use flexible bus service (service price is set equal to three euros, the trip is no longer than 30 min in-vehicle travel time).

Regarding the spatial dimension of the aforementioned elements, the following should be acknowledged. The settlement distribution within the study area reveals distinct patterns and characteristics. Notably, larger populations tend to cluster along the coastal regions, fostering a coastal urbanization trend. Tellingly, Corinth and Loutraki form a dipole due to population size and geographical proximity. Next, it should be mentioned that various types of points of interest have been identified, and they are categorized as follows: (a) cultural sites (including museums and archaeological sites), (b) natural sites, (c) beaches, and (d) other points of interest. More specifically, there are 90 natural attractions, 160 cultural points of interest, 60 beaches, and 4 other points of interest. The area exhibits a distinctive distribution of points of interest, appearing scattered; however, spatial analysis indicates clustering (NNA = 0.57). Within the urban area of Corinth, a total of 211 point-based non-residential land uses have been recorded, divided into 11 distinct categories (see Figure 7b). In Corinth itself, non-residential land uses, particularly commercial and recreational facilities, dominate, especially within the central area, encompassing a significant share of 61.61%. The suburban railway system covers a length of 34.9 km within the study area and three stations: Zevgolateio, Corinth, and Agioi Theodoroi. The regional bus lines operate in a road network of 190.5 km length, and there is also a local bus service that facilitates short-distance routes with a total length of about 16.1 km.



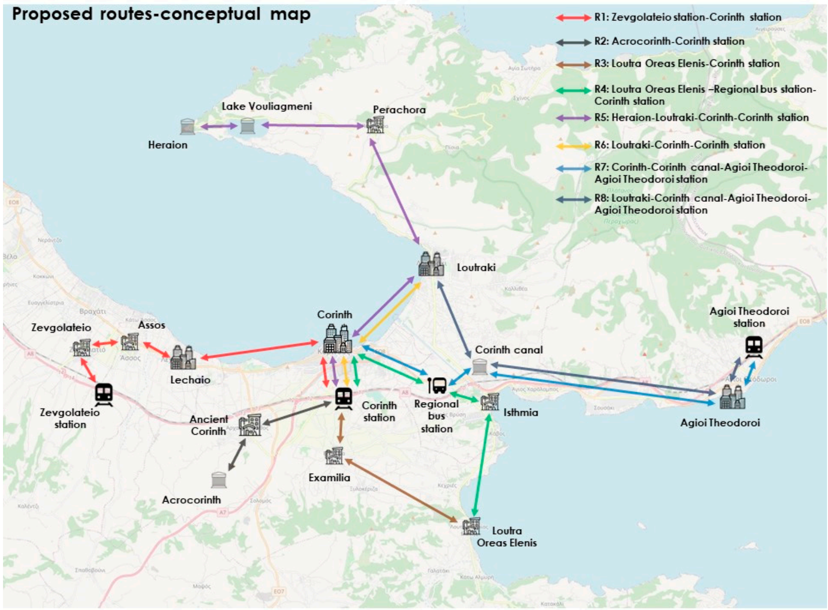
(**a**)



(**b**)

Figure 7. (**a**) Boundary, population, road hierarchy, and (**b**) POI, bus routes, stations, land uses—mini maps.

Next, the conceptual connections were determined (see Figure 8a). The proposed flexible bus network encompasses eight routes. Route 1 (R1) connects the Zeugolateio and Corinth suburban railway stations, passing through settlements like Zeugolateio and Assos, as well as urban centers such as Lechaio and Corinth. This route initially serves the suburban railway, playing an important feeding role. Route 2 (R2) primarily focuses on catering to touristic destinations. It begins at the Corinth railway station, establishing a connection to Ancient Corinth and further linking this settlement to Acrocorinth, which are two of the most important points of interest in the wider area. Route 3 (R3) functions as a feeder service for the suburban railway, connecting the Corinth suburban railway station to Loutra Oreas Elenis, with a route passing through the settlement of Examilia. Notably, Route 4 (R4) serves a dual purpose: connecting settlements to urban centers and providing service to the suburban railway. It connects the Corinth station to Loutra Oreas Elenis, following a path through Isthmia (differing from Route 3). Hence, it integrates the regional bus station at the Isthmus.



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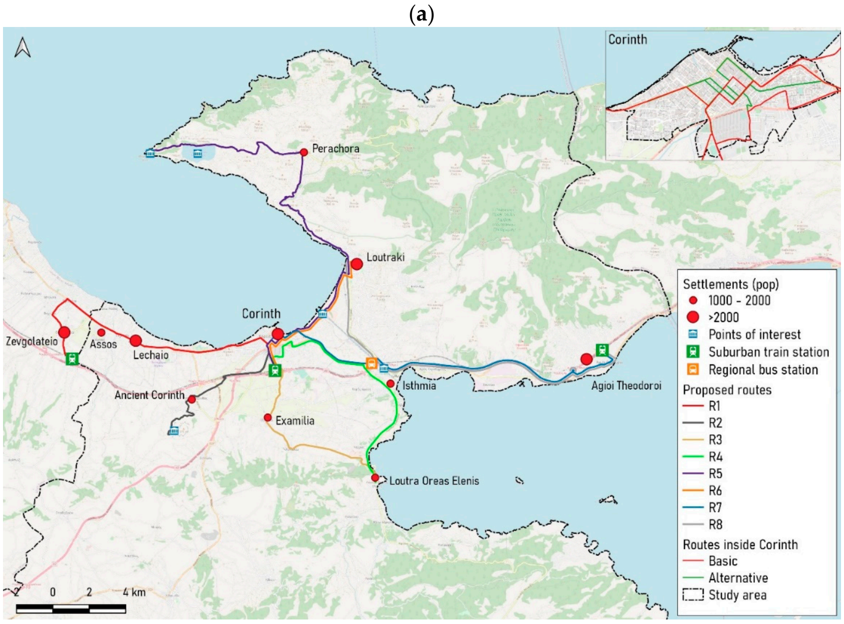

(**b**)

Figure 8. Proposed routes (**a**) conceptual planning diagram (**b**) actual paths.

Moving to rest routes, Route 5 (R5) is a comprehensive route addressing four key aspects: servicing the suburban railway, connecting settlements to urban centers, linking major urban centers with each other, and catering to touristic destinations. Starting from the Heraion archaeological site, it terminates at the suburban railway station in Corinth. Along this route, connections are established between Heraion, Lake Vouliagmeni, and Perachora, benefiting the tourist destinations. Consequently, the settlement of Perachora becomes linked to Loutraki, Corinth, and ultimately to the railway station in Corinth. Route 6 (R6) starts from Loutraki, passes through Corinth, and terminates at the Corinth railway station. This route effectively connects the two major urban centers of Loutraki and Corinth. Route 7 (R7) offers feeder service to the suburban railway, links settlements to urban centers, and caters to touristic destinations. Originating from Corinth, it traverses the regional bus station in Isthums, the Corinth Canal, the urban center of Agioi Theodori, and terminates at the suburban railway station of Agioi Theodori. Finally, Route 8 (R8) has a dual focus: serving touristic destinations and providing feeder service to the suburban railway. It connects Loutraki, the Corinth Canal, and Agioi Theodori, facilitating visitors to the Corinth Canal. Furthermore, it connects Agioi Theodori with the railway station outside the city. The actual route paths are presented in Figure 8b.

An overview table portraying the basic characteristics of each route is given in Appendix A (e.g., travel time, train stations, significance, etc.). Subsequently, a descriptive statistical analysis was conducted for the entire set of routes. The outcomes are presented in the appendix too. Overall, most of the routes have lengths over 10 km, and the maximum value is encountered in R5, which is nearly 30 km. The collection points vary from only 5 (R2 and R3) to 29 (R5), and the estimated travel time has a mean of 22.50 min; however, it ranges from 15 (R3) to 44 min (R5). Notably, the route facilitating the most train stations is R1 (Zevgolateio and Corinth). Regarding the land use mix, the mean value is 0.38 (relatively low); nevertheless, Route 5 portrays a value of 0.71, reflecting considerable diversity in land uses. The main identities are serving touristic destinations (frequency of 4), and the population served varies from only 1939 (R2) to 42943 (R5). Finally, discontinuity of hierarchy, a major factor influencing the efficiency of a route, has a mean value of 8.38. The route with the most continuous route is R3. In the following table (Table 4), one can see the deviation from the straight line (Euclidean distance) and the number of passenger collection points between evening and morning regarding routes passing the main urban center of Corinth. As can be observed, the difference is appreciable in many cases (e.g., R1, R4, and R5).

Table 4. Characteristics of flexible bus routes for morning and evening.

Route	Deviation from Euclidean Distance		Collection Points (Based on Land Uses)	
	Evening	Morning	Evening	Morning
R1	59.46%	63.77%	19	21
R4	76.81%	74.18%	9	10
R5	96.87%	101.16%	21	24
R6	17.07%	25.43%	15	18
R7	2.36%	1.12%	18	13

Subsequently, four alternative solutions addressing passenger collection points in the city of Corinth are delineated. Particularly, distance intervals of 200 m, 300 m, 400 m, and 500 m were examined. Additionally, a buffer with a radius of 150 m was applied to each category, corresponding to a 2.5-min walking distance. It should be noted that the passenger collection points were created separately for each route, considering only the distance between them. The results can be seen in Figure 9.

3.3. Assessment Outcomes

The evaluation of the eight proposed routes was based on eight criteria, which were divided into three groups: demographic, urban planning, and transportation-related criteria. Concerning the routes passing through Corinth, under an equal-weight approach, Route R6 is favored as the top choice, followed by R7 in second place, and R1 in third. Route R5 ranks fourth, while Route R4 presents almost negligible probability. When applying a demographic-oriented approach as the primary criteria group, once again, Route R6 takes the lead, followed by R5 in second place, and then R7. Route R1 ranks fourth, and Route R4 exhibits no significant probability. Regarding the unequal-weight approach with an emphasis on urban planning criteria, Route R5 secures the first position. The route with the next highest probability is R6, followed by R7 in third, R1 in fourth, and R4 with minimal likelihood. Finally, in the unequal-weight analysis based on transportation-related criteria, Route R6 significantly outperforms the others, securing the top position. R7 ranks second, R1 is in third place, R4 is fourth, and finally, Route R5 has the lowest probability. All these rankings can be found in Figure 10.

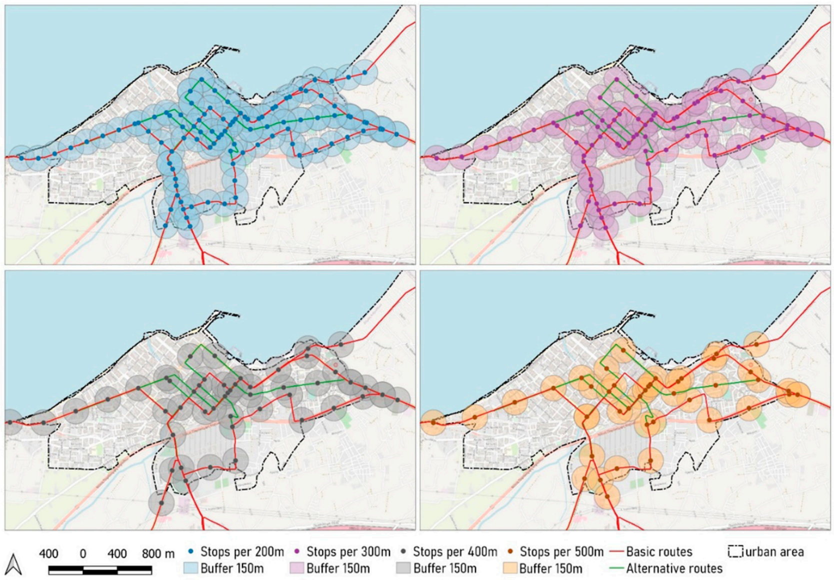

Figure 9. Collection points based on a distance criterion (point every 200 m, 300 m, 400 m, and 500 m).

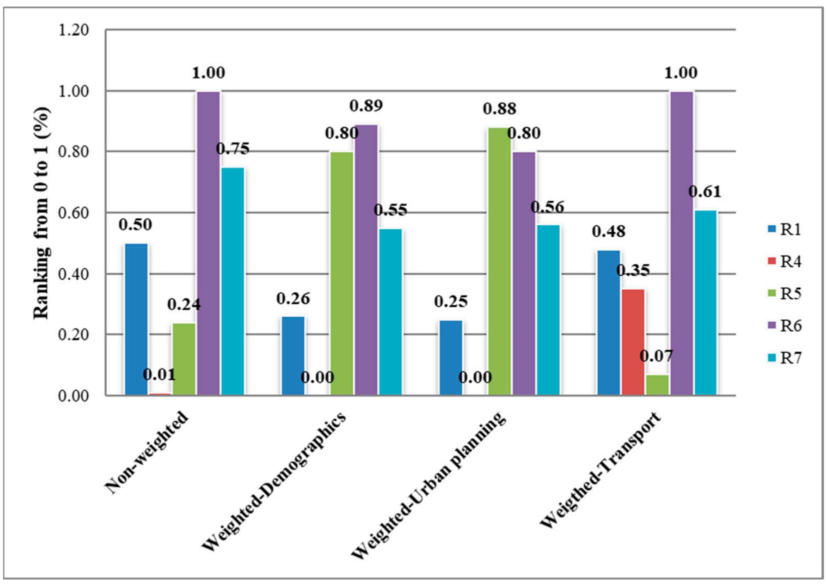

Figure 10. Multi-criteria analysis of flexible bus service routes inside Corinth.

The results reflect a considerable complexity when it comes to ranking the routes passing through Corinth. Taking into account the multiple multicriteria analysis procedures, an overall result could be the following: R6, R7, R5, R1, and R4. With respect to the routes outside Corinth (meaning that they do not pass through the city), the same criteria are considered. Notably, for both the equal-weight and unequal-weight approaches, Route R8 stands out as the top choice. Route R3 comes in second place in the equal-weight analysis and ranks second in the evaluation iterations emphasizing urban planning and transportation-related criteria. Route R2 presents negligible or almost negligible values, with an exception encountered though in the case of unequal-weight evaluation focusing on demographic criteria, where it ranks second. The results in this case are relatively homogeneous. Route 8 is ranked as the most preferable choice, which should be prioritized for implementation; R3 holds the second position, and R2 should be placed at the final position, signifying low levels of priority (see Figure 11).

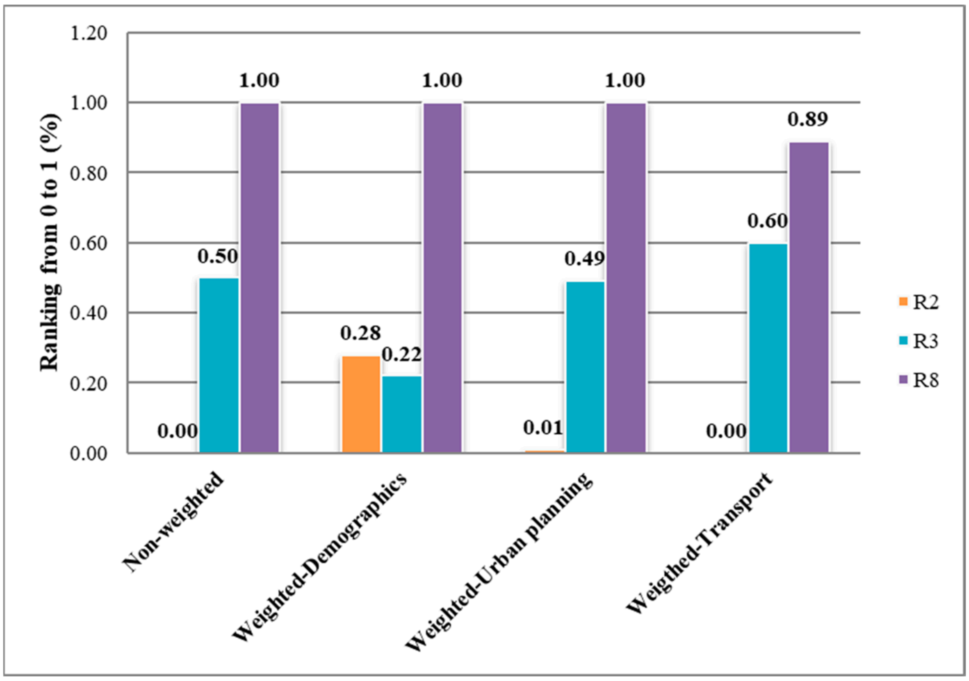

Figure 11. Multi-criteria analysis of flexible bus service routes outside Corinth.

4. Discussion

This research aimed to identify factors influencing the willingness to use flexible services and to plan efficient and effective routes that comply with these factors. Questionnaire survey, spatial analysis, and multicriteria analysis techniques were employed. To the authors' knowledge, similar research attempts have not adopted such a holistic approach. Mainly, they either focus on questionnaires like Thao et al. [44] and Jittrapirom et al. [45] or on planning [27,28]. Additionally, multicriteria decision-making has been used quite rarely and mostly on evaluating the entire scheme and not the proposed routes [22]. This approach offers several distinct advantages over previous studies that primarily focused on optimizing on-demand service responsiveness or defining optimal routes [6,27,28]. The proposed planning method achieves a practical solution that delivers a simple and feasible public transport service. A key strength of this approach is its high level of customization: the service is specifically designed to align with local land use patterns and user preferences. Consequently, the bus makes several deviations to meet high demand needs. To this end, spatiotemporal variations in demand should be adequately forecasted before designing such a "realistic flexible" service [26]. This method also includes policymakers and planners directly in the co-formulation process, ensuring that the service aligns with local objectives.

When it comes to questionnaire surveys, this research quantified the operational factors of a flexible bus service, intending to seek an efficient and concurrently effective design and thus rendering the service more appealing to users. Influential factors to be tested, such as cost, delays, connectivity to areas with low service coverage, congestion, etc., emerged from a narrative literature review. Undoubtedly, cost and time are two statistically significant utility variables. This is in line with relevant studies [13,15]. However, in this study, an advanced analysis of model outputs was performed to unveil the cost associated with various time components of a public transport trip, i.e., in-vehicle, waiting, and walking times, during different times of the day. As a general conclusion, during the morning peak, users are notably disinclined to walk to the nearest passenger pickup point, in contrast to evening hours where walking to the stop is not a deterrence. Comparatively, during the afternoon peak, extended waiting times decrease the service's appeal. This is related to the activities that are performed in each period of the day. Indeed, the time cost holds the highest value during the afternoon peak when commuters are "rushing" to return home. Thus, the service should be more efficient during this period. But during the morning peak, based on the results, the design should focus on a door-to-door service, reducing walking times significantly from/to work locations. These findings are particularly interesting when aligned with the existing literature, which suggests that on-demand services should be prioritized during afternoon peak hours [46]. Overall, it is noteworthy that users are unwilling to pay more than 3.5 euros for a 20-min journey using this new mode of transport. This relatively high price elasticity underscores the potential profitability of offering such a customized mobility solution. A diagram showing the main inputs coming from the stated preferences experiment to the planning process is shown in Figure 12.

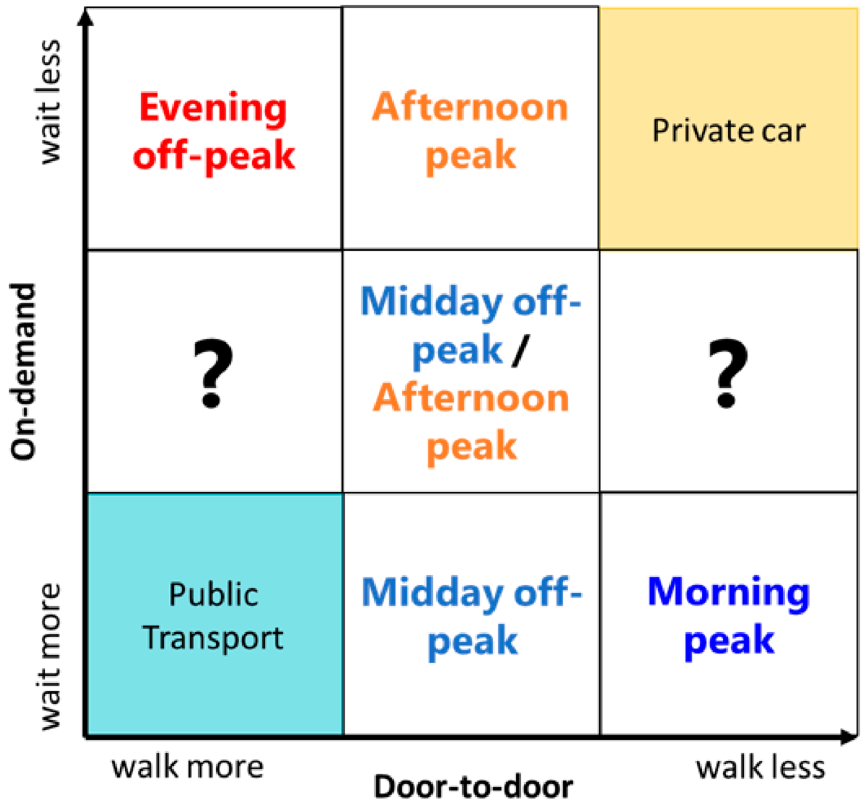

Figure 12. Overview of a flexible bus service based on different demand needs (unmatched cells are indicated with "?").

Regarding socio-demographic characteristics, age and gender matter [17]. Noticeably, it was revealed that women are more interested in using this flexible service, in line with Terry and Bachmann [18]. Conversely, concerning men, even minor price fluctuations lead to substantial changes in the intent to use the new service. The same applies to individuals aged 18–29. This is indeed interesting since the existing literature has not reached a consensus. For instance, Anburuvel et al. [17] indicated that younger people are more likely to use flexible bus services; on the contrary, Knierim and Schluter [20] demonstrated that the elderly (especially in rural areas) are keen on choosing such a scheme. Depending on these results, pricing policies should be accordingly adjusted to ensure affordable conditions for all users [47].

The spatial planning of the routes appears to be a time-consuming process, but it involves crucial details. The preferences of respondents to the questionnaire were taken seriously into account. This is exactly the meaning of the adopted holistic approach: to make synergies between the questionnaire and spatial analysis. An effort was made to clarify the success factors of a flexible bus service adapted to the demand. Noticeably, demand also has a spatial structure; hence, land uses were investigated in this paper. This can be found in similar research by Wang et al. [22]. The study area was thoroughly examined, and the proposed solutions are tailored to the characteristics of the area. This research serves as a guide for designing similar flexible bus routes in other regional cities in Greece and beyond in the Mediterranean context. This is because the attraction points are limited and concentrated in the city centers. Like many other cities, Corinth is monocentric, with a railway station located outside the central core. Simultaneously, there are suburban and interurban settlements with low road network connectivity to the center. Therefore, the solution groups are quite limited. The latter, as evident, demonstrates the importance and compatibility of the proposed methodology in planning flexible bus lines. These findings are not usually found in the literature since several articles emphasize optimization algorithms and machine learning, which can handle and evaluate more extensive solutions [27]. In complex transportation systems, such as those in metropolitan areas, they can prove to be more useful.

Focusing on the study area, a total of eight different routes were presented for the flexible bus service. These are divided into four groups according to their respective serving purposes, complying with the conceptual planning process: (a) train feeder, (b) connecting settlements to urban centers, (c) connecting main urban centers, and (d) serving touristic destinations. Furthermore, the routes are ranked based on their significance using the REGIME multi-criteria evaluation method. REGIME has been used in similar studies but not in route planning. Therefore, this study encapsulates multicriteria analysis in route planning. This ranking assists in selecting the route that the flexible bus service will operate based on the demand and operational cost constraints. In other words, this ranking may help policymakers and transport providers decide which routes should operate first.

When it comes to routes passing through Corinth, ranking reflected complexity; on the other hand, concerning routes that do not reach Corinth, results were homogeneous. Routes 6 and 8 were deemed the most critical from this analysis for areas outside and within Corinth, respectively. Hence, at a strategic level, there is a wide range of line choices available to the regional bus services. At an operational level, the transport project manager selects which lines will operate, always considering passenger demands. This selection should be made daily to ensure a truly dynamic service. Additionally, the routes are modified throughout the day, considering the survey results. This is partially in line with Iqbal et al. [48], who proposed intelligent bus stops that will be effective or ineffective depending on the occurring demand.

With regards to the passenger collection points (only) within Corinth, four alternative solutions are presented, differing in their distance density. High density offers shorter walking distances for most building blocks in the city. Based on the analysis process, it is evident that the city of Corinth is adequately covered by the 300 m and 400 m density values. Therefore, there is no need to implement a denser solution. This spatial approach could contribute to implementing flexible bus services in real-life conditions. Transport operators could test these intervals and decide which is the most efficient for balancing operational conditions and walking requirements.

Despite its notable contribution, this research illustrates some limitations that should be addressed at this point. First and foremost, the sample of the survey is characterized by a low representation of elderly individuals, as the questionnaire was exclusively distributed online. As the primary users of public transport today, it is certain that this service will attract them. What is more, the survey results reflect the preferences of local residents only, meaning that applying the proposed method would require the recalibration of the demand model by conducting the same stated preference experiment. A restraining factor might be familiarity with technology, though this depends more on the design of the electronic platform and less on the design of bus routes. Regarding the flexibility of the planning method, it should be underlined that the method also has some drawbacks. It tends to be more static than dynamic, concentrating on finite routes. The dynamic nature relies on the different number of stops per morning and evening. However, this is suitable for urban–rural areas, but it would be a significant limitation for complex metropolitan cities. Additionally, routes utilized existing infrastructure; a discussion about building new roads was not on the table in this study. Furthermore, the conceptual design was mainly based on geographical thinking and the importance of points of interest rather than an optimization technique. Finally, when looking into the evaluation of the routes, the criteria are limited, representing certain categories (demographic, urban, and transport); new perspectives should be explored in the future.

The future of research in the field of route planning holds tremendous promise, with novel algorithms and machine-learning techniques at the forefront of innovation. One exciting avenue of research lies in developing algorithms that can adapt in real time to changing traffic conditions, ensuring efficient and time-saving routes. Incorporating machine learning into route planning can enable systems to learn from historical data, user preferences, and real-time traffic updates, resulting in more personalized and context-aware recommendations. Advanced spatial tools are another frontier in route planning research. These tools leverage the power of geographic information systems (GIS) to provide users with an even deeper understanding of their surroundings. For instance, 3D mapping and visualization can offer a more immersive and accurate depiction of the terrain, allowing for better route selection, especially in complex urban landscapes or natural environments. Furthermore, the integration of augmented reality (AR) into navigation apps can overlay real-time information, such as points of interest, traffic signals, or even potential hazards.

Expanding the evaluation criteria for route planning systems is crucial for ensuring they meet the diverse needs of users. While traditional criteria often focus on distance and travel time, the future of research should encompass a wider range of factors. These could include energy efficiency, carbon footprint, and even the impact on mental well-being. Accessibility and equity implications are fundamental aspects of future route planning research. Public transport systems must be designed with inclusivity in mind, addressing the needs of all individuals, including those with disabilities. In the future, route planning systems could also play a pivotal role in promoting sustainable and eco-friendly modes of transportation. By encouraging users to choose routes that minimize their carbon footprint, these systems can contribute to reducing greenhouse gas emissions and combating climate change. Additionally, incorporating dynamic pricing models into route planning research can help optimize traffic flow and reduce congestion during peak hours.

5. Conclusions

This research represents a significant step forward in the field of transportation planning by utilizing a holistic approach to examine user behavior and route planning for a flexible bus service. The findings underscore the critical importance of such services, particularly in urban and rural areas where automobility prevails and traditional public transport options are quite limited. Through a comprehensive questionnaire survey, it was evident that people not only embrace the concept of flexible bus services but also have apparent preferences for their deployment: a door-to-door system during morning peaks with more stops, transitioning to a flexible system with fewer stops during evening peaks. Furthermore, the research introduced a novel approach to route planning, combining strategic thinking and spatial analysis techniques, which is a pioneering effort in this domain. Utilizing a questionnaire, spatial analysis, and multicriteria decision tools ensured the comprehensiveness and trustworthiness of the research.

The potential benefits of implementing these flexible services in urban–rural contexts are clear, and the method's adaptability ensures it can be readily adopted by similar settings, contributing to more efficient and user-centric transportation solutions. In summary, this research offers valuable insights and a practical framework for enhancing flexible transportation services while considering the diverse needs and preferences of users as well as supporting transport providers and policymakers. There is an ongoing debate on flexible bus services; this research contributes to it but also calls for new research uptakes that will shed light further, preparing the background for sustainable and efficient public transport. By embracing novel ideas and fostering interdisciplinary collaborations, public transport systems that are not just efficient but also sustainable, equitable, and user-centric will be realized.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki. The overall research project has been approved by the Ethics Committee of Research of the National Technical University of Athens (project/approval code: 68147800).

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: Dataset available on request from the authors.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Binary logistic regression model results.

Parameters	Est.	Std. Error	z	*p*-Value
Core parameters				
Intercept	3.026	0.288	10.794	<0.001
price in euros	−0.344	0.046	−7.449	<0.001
in-vehicle time in minutes	−0.067	0.012	−5.451	<0.001
waiting time in minutes	−0.097	0.022	−4.369	<0.001
walking time in minutes	0.086	0.026	3.273	0.001
Interactions				
in-vehicle time in minutes × morning peak period (1, if yes)	0.094	0.015	6.120	<0.001
waiting time in minutes × morning peak period (1, if yes)	0.138	0.030	4.596	<0.001
walking time in minutes × morning peak period (1, if yes)	−0.291	0.035	−8.385	<0.001
in-vehicle time in minutes × midday off-peak period (1, if yes)	0.038	0.015	2.501	0.012
waiting time in minutes × midday off-peak period (1, if yes)	0.056	0.028	1.998	0.046
walking time in minutes × midday off-peak period (1, if yes)	−0.134	0.032	−4.177	<0.001
in-vehicle time in minutes × afternoon peak period (1, if yes)	0.050	0.016	3.179	0.002
waiting time in minutes × afternoon peak period (1, if yes)	0.031	0.028	1.143	0.253
walking time in minutes × afternoon peak period (1, if yes)	−0.143	0.032	−4.433	<0.001
Socio-demographic characteristics				
gender (1, if male)	−0.327	0.109	−3.012	0.003

Table A1. *Cont.*

Parameters	Est.	Std. Error	z	*p*-Value
age group 18–29 (1, if yes)	−0.464	0.110	−4.227	<0.001
Number of respondents	181			
Number of observations	1611			
Number of estimated parameters	16			
Null log-likelihood	−1103			
Log-likelihood at convergence	−993.1			
McFadden's ρ	0.099			

Table A2. Overview of the routes.

Route	Length (km)	Travel Time (min)	Collection Points	Train Station	Significance	Land Uses Along	Land Use Mix (Entropy Index)	Main Identity	Population Served	Discontinuity of Hierarchy
1	17.96	26.00	25	2	High	27	0.23	Train feeder	38,133	10.00
2	10.66	16.00	5	1	Moderate	3	0.00	Touristic destination	1939	10.00
3	11.54	15.00	5	1	Moderate	1	0.00	Touristic destination	4688	3.00
4	15.45	18.00	16	1	Moderate	8	0.35	Connect urban centers with settlements	32,688	5.00
5	27.83	44.00	29	1	High	87	0.71	Touristic destination	42,943	15.00
6	9.12	17.00	23	1	High	45	0.56	Connect urban centers	41,740	9.00
7	22.11	23.00	22	1	High	45	0.65	Connect urban centers	35,503	9.00
8	21.25	21.00	12	1	High	47	0.56	Touristic destination	16,891	6.00

Table A3. Statistical quantitative data about proposed routes.

	Length (km)	Travel Time (min)	Land Uses Along	Land Use Mix (Entropy Index)	Population Served	Discontinuity of Hierarchy
Mean	16.99	22.50	33	0.38	26,816	8.38
Maximum value	27.83	44.00	87	0.71	42,943	15.00
Minimum value	9.12	15.00	1	0.00	1939	3.00
Standard deviation	6.51	9.46	29.24	0.28	16,596	3.70

References

1. Milakis, D.; Vlastos, T.; Barbopoulos, N. Relationships between Urban Form and Travel Behaviour in Athens, Greece. A Comparison with Western European and North American Results. *Eur. J. Transp. Infrastruct. Res.* **2008**, *8*. [CrossRef]
2. Estrada, M.; Salanova, J.M.; Medina-Tapia, M.; Robusté, F. Operational Cost and User Performance Analysis of On-Demand Bus and Taxi Systems. *Transp. Lett.* **2021**, *13*, 229–242. [CrossRef]
3. Frost and Sullivan. *Strategic Analysis of the Global Demand-Responsive Transit (DRT) Market, Forecast to 2030*; Frost and Sullivan: San Antonio, TX, USA, 2018.
4. Institution of Mechanical Engineers, Community Transport Association. *The Future of Demand Responsive Transport*; Institution of Mechanical Engineers, Community Transport Association: London, UK, 2018.
5. Brake, J.; Nelson, J.D.; Wright, S. Demand Responsive Transport: Towards the Emergence of a New Market Segment. *J. Transp. Geogr.* **2004**, *12*, 323–337. [CrossRef]
6. Chu, J.C.-Y.; Chen, A.Y.; Shih, H.-H. Stochastic Programming Model for Integrating Bus Network Design and Dial-a-Ride Scheduling. *Transp. Lett.* **2022**, *14*, 245–257. [CrossRef]
7. Laws, R.; Enoch, M.; Ison, S.; Potter, S. Demand Responsive Transport: A Review of Schemes in England and Wales. *J. Public Transp.* **2009**, *12*, 19–37. [CrossRef]
8. Helsinki Regional Transport Authority. *Kutsuplus–Final Report. Helsinki, Finland*; Helsinki Regional Transport Authority: Helsinki, Finland, 2016.
9. Cohen, A.; Shaheen, S. *Planning for Shared Mobility*; American Planning Association: Washington, DC, USA, 2018.
10. Westervelt, M.; Huang, E.; Schank, J.; Borgman, N.; Fuhrer, T.; Peppard, C.; Narula-Woods, R. *UpRouted: Exploring Microtransit in the United States*; Eno Center for Transportation: Washington, DC, USA, 2018.
11. Davison, L.; Enoch, M.; Ryley, T.; Quddus, M.; Wang, C. A Survey of Demand Responsive Transport in Great Britain. *Transp. Policy* **2014**, *31*, 47–54. [CrossRef]

12. König, A.; Grippenkoven, J. The Actual Demand behind Demand-Responsive Transport: Assessing Behavioral Intention to Use DRT Systems in Two Rural Areas in Germany. *Case Stud. Transp. Policy* **2020**, *8*, 954–962. [CrossRef]
13. Torrisi, V.; Inturri, G.; Ignaccolo, M. Introducing a Mobility on Demand System beyond COVID-19: Evidences from Users' Perspective. In Proceedings of the International Conference of Computational Methods in Sciences and Engineering ICMSE 2020, Crete, Greece, 29 April–3 May 2020; p. 090007.
14. Campisi, T.; Canale, A.; Ticali, D.; Tesoriere, G. Innovative Solutions for Sustainable Mobility in Areas of Weak Demand. Some Factors Influencing the Implementation of the DRT System in Enna (Italy). In Proceedings of the International Conference of Computational Methods in Sciences and Engineering ICCMSE 2020, Crete, Greece, 29 April–3 May 2020; p. 090005.
15. Bronsvoort, K.; Alonso-González, M.; Van Oort, N.; Molin, E.; Hoogendoorn, S. Preferences toward Bus Alternatives in Rural Areas of the Netherlands: A Stated Choice Experiment. *Transp. Res. Rec.* **2021**, *2675*, 524–533. [CrossRef]
16. Schasché, S.E.; Sposato, R.G.; Hampl, N. User Acceptance of Demand-Responsive Transport Services in Rural Areas: Applying the UTAUT to Identify Influencing Latent Constructs. In Proceedings of the IEWT 2021, Wien, Austria, 8–10 September 2021; Available online: https://iewt2021.eeg.tuwien.ac.at (accessed on 10 September 2024).
17. Anburuvel, A.; Perera, W.U.L.D.P.; Randeniya, R.D.S.S. A Demand Responsive Public Transport for a Spatially Scattered Population in a Developing Country. *Case Stud. Transp. Policy* **2022**, *10*, 187–197. [CrossRef]
18. Terry, J.; Bachmann, C. Estimating Suburban Preferences for Integrated Public Transit and Ridesourcing Services through a Revealed-Preference/Stated-Preference Survey. *J. Public Transp.* **2023**, *25*, 100047. [CrossRef]
19. Frei, C.; Hyland, M.; Mahmassani, H.S. Flexing Service Schedules: Assessing the Potential for Demand-Adaptive Hybrid Transit via a Stated Preference Approach. *Transp. Res. Part C Emerg. Technol.* **2017**, *76*, 71–89. [CrossRef]
20. Knierim, L.; Schlüter, J.C. The Attitude of Potentially Less Mobile People towards Demand Responsive Transport in a Rural Area in Central Germany. *J. Transp. Geogr.* **2021**, *96*, 103202. [CrossRef]
21. Ryley, T.J.; Stanley, P.A.; Enoch, M.P.; Zanni, A.M.; Quddus, M.A. Investigating the Contribution of Demand Responsive Transport to a Sustainable Local Public Transport System. *Res. Transp. Econ.* **2014**, *48*, 364–372. [CrossRef]
22. Wang, J.; Liu, K.; Yamamoto, T.; Wang, D.; Lu, G. Built Environment as a Precondition for Demand-Responsive Transit (DRT) System Survival: Evidence from an Empirical Study. *Travel Behav. Soc.* **2023**, *30*, 271–280. [CrossRef]
23. Charisis, A.; Iliopoulou, C.; Kepaptsoglou, K. DRT Route Design for the First/Last Mile Problem: Model and Application to Athens, Greece. *Public Transp.* **2018**, *10*, 499–527. [CrossRef]
24. Faroqi, H.; Sadeghi-Niaraki, A. GIS-Based Ride-Sharing and DRT in Tehran City. *Public Transp.* **2016**, *8*, 243–260. [CrossRef]
25. Triantafillidi, E.; Tzouras, P.G.; Spyropoulou, I.; Kepaptsoglou, K. Identification of Contributory Factors That Affect the Willingness to Use Shared Autonomous Vehicles. *Future Transp.* **2023**, *3*, 970–985. [CrossRef]
26. Lee, H.; Choi, C.-W.; Cho, S.-H.; Park, H.-C. Pre-Peak Fare Discount Policy for Managing Morning Peak Demand of Interregional Bus Travel: A Case Study in Seoul Metropolitan Area. *Transp. Lett.* **2024**, *16*, 1059–1068. [CrossRef]
27. Bruni, M.E.; Guerriero, F.; Beraldi, P. Designing Robust Routes for Demand-Responsive Transport Systems. *Transp. Res. Part E Logist. Transp. Rev.* **2014**, *70*, 1–16. [CrossRef]
28. Carotenuto, P.; Serebriany, A.; Storchi, G. Flexible Services for People Transportation: A Simulation Model in a Discrete Events Environment. *Procedia-Soc. Behav. Sci.* **2011**, *20*, 846–855. [CrossRef]
29. Hensher, D.A. Stated Preference Analysis of Travel Choices: The State of Practice. *Transportation* **1994**, *21*, 107–133. [CrossRef]
30. Molin, E.; Blangé, J.; Cats, O.; Chorus, C. Willingness to Pay for Safety Improvements in Passenger Air Travel. *J. Air Transp. Manag.* **2017**, *62*, 165–175. [CrossRef]
31. Tzouras, P.G.; Pastia, V.; Kaparias, I.; Kepaptsoglou, K. Exploring the Effect of Perceived Safety in First/Last Mile Mode Choices. *Transportation* **2024**, 1–39. [CrossRef]
32. Porru, S.; Misso, F.E.; Pani, F.E.; Repetto, C. Smart Mobility and Public Transport: Opportunities and Challenges in Rural and Urban Areas. *J. Traffic Transp. Eng. Engl. Ed.* **2020**, *7*, 88–97. [CrossRef]
33. Tsigdinos, S.; Karolemeas, C.; Bakogiannis, E.; Nikitas, A. Introducing Autonomous Buses into Street Functional Classification Systems: An Exploratory Spatial Approach. *Case Stud. Transp. Policy* **2021**, *9*, 813–822. [CrossRef]
34. Browne, D.; Ryan, L. Comparative Analysis of Evaluation Techniques for Transport Policies. *Environ. Impact Assess. Rev.* **2011**, *31*, 226–233. [CrossRef]
35. Huang, I.B.; Keisler, J.; Linkov, I. Multi-Criteria Decision Analysis in Environmental Sciences: Ten Years of Applications and Trends. *Sci. Total Environ.* **2011**, *409*, 3578–3594. [CrossRef]
36. Sun, H.; Zhang, Y.; Wang, Y.; Li, L.; Sheng, Y. A Social Stakeholder Support Assessment of Low-Carbon Transport Policy Based on Multi-Actor Multi-Criteria Analysis: The Case of Tianjin. *Transp. Policy* **2015**, *41*, 103–116. [CrossRef]
37. Milakis, D.; Athanasopoulos, K.; Vafeiadis, E.; Vasileiadis, K.; Vlastos, T. Planning of the Athens Metropolitan Cycle Network Using Participative Multicriteria Gis Analysis. *Procedia-Soc. Behav. Sci.* **2012**, *48*, 816–826. [CrossRef]
38. Vermote, L.; Macharis, C.; Boeykens, F.; Schoolmeester, C.; Putman, K. Traffic-Restriction in Ramallah (Palestine): Participatory Sustainability Assessment of Pedestrian Scenarios Using a Simplified Transport Model. *Land Use Policy* **2014**, *41*, 453–464. [CrossRef]
39. Vreeker, R.; Nijkamp, P.; Ter Welle, C. A Multicriteria Decision Support Methodology for Evaluating Airport Expansion Plans. *Transp. Res. Part D Transp. Environ.* **2002**, *7*, 27–47. [CrossRef]

40. Spiekermann, K.; Wegener, M. Evaluating Urban Sustainability Using Land-Use Transport Interaction Models. *Eur. J. Transp. Infrastruct. Res.* **2004**, *4*. [CrossRef]
41. Tsigdinos, S.; Paraskevopoulos, Y.; Tzouras, P.G.; Kepaptsoglou, K. Development of a Complete Method for Re-Conceptualizing Street Classification in an Urban Municipality. *J. Transp. Geogr.* **2024**, *121*, 104025. [CrossRef]
42. Imhof, S.; Blättler, K. Assessing Spatial Characteristics to Predict DRT Demand in Rural Switzerland. *Res. Transp. Econ.* **2023**, *99*, 101301. [CrossRef]
43. Alonso-González, M.J.; Van Oort, N.; Cats, O.; Hoogendoorn-Lanser, S.; Hoogendoorn, S. Value of Time and Reliability for Urban Pooled On-Demand Services. *Transp. Res. Part C Emerg. Technol.* **2020**, *115*, 102621. [CrossRef]
44. Thao, V.T.; Imhof, S.; Von Arx, W. Demand Responsive Transport: New Insights from Peri-Urban Experiences. *Travel. Behav. Soc.* **2023**, *31*, 141–150. [CrossRef]
45. Jittrapirom, P.; Van Neerven, W.; Martens, K.; Trampe, D.; Meurs, H. The Dutch Elderly's Preferences toward a Smart Demand-Responsive Transport Service. *Res. Transp. Bus. Manag.* **2019**, *30*, 100383. [CrossRef]
46. Chandra, S.; Quadrifoglio, L. A Model for Estimating the Optimal Cycle Length of Demand Responsive Feeder Transit Services. *Transp. Res. Part B Methodol.* **2013**, *51*, 1–16. [CrossRef]
47. Guzman, L.A.; Arellana, J.; Oviedo, D.; Castaño Herrera, D.; Sarmiento, O.L. Lifting Urban Mobility for the Poor: Cable-Cars, Travel Satisfaction and Subjective Well-Being. *Transp. Res. Part D Transp. Environ.* **2023**, *119*, 103765. [CrossRef]
48. Iqbal, R.; Ghani, M.U. Intelligent Bus Stops in the Flexible Bus Systems. *J. Eng. Sci. Technol. Rev.* **2014**, *7*, 59–65. [CrossRef]