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Transport Mode Choice for Residents in a Tourist Destination: The Long Road to Sustainability (the Case of Mallorca, Spain)

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Abstract: Sustainable mobility policies may encounter social, economic, and cultural barriers to successful implementation that need to be assessed. In this sense, knowledge of the population's mobility habits and their relationship with transport modes is particularly essential. Along these lines, a study was carried out of the patterns of transport modes chosen concerning various social and territorial variables on the island of Mallorca based on the most recent mobility surveys. The study shows that the choice of mode is influenced by a wide range of factors, such as gender, age group, motive for the trip, occupation, region of residence, duration of the trip, and proximity to Palma, the capital of the island. The results indicate that private vehicles are the most often chosen mode of transport. Private vehicles are mainly used by working men between 30 and 44 years old for journeys between home and work, which do not exceed 30 min and are preferably in areas close to Palma. Sustainable modes are little used, although they are mainly used by women, young people, and retired people for work purposes and for access to educational and health centers. The demand for transport generated by the resident population and tourist activity and the negative externalities generated by mobility in private vehicles are closely related on a municipal level (Pearson's coefficient 0.84, $p = 0.00$). However, the modal distribution does not seem to be directly related to these factors. Instead, it develops a more conditioned distribution by access to rail transport infrastructures and other geographical factors. In recent years, the Balearic Islands' public administration launched the Balearic Islands Sectorial Mobility Plan 2019–2026, which aims to promote sustainable modes and reduce the use of private vehicles. This plan represents a considerable economic investment, but will also require great institutional coordination and cultural changes in the population's perception of mobility. The study shows that the implementation of sustainable modes on the island requires a global vision of mobility issues that integrates urban planning and tourism planning to make the land-use model more sustainable.

Keywords: modal choice; sustainable mobility; Mallorca mobility; logistic regression; transport planning

1. Introduction

The path towards implementing a sustainable transport model in a territory is a long and complicated process that involves a broad series of changes and transformations that must be carried out in a harmonized way over time and space [1–3]. Some of these transformations are structural and require large-scale economic investments, such as construction of or improvements in sustainable transport infrastructures (roads, highways, railways, trams, subways, bike lanes, etc.) [4], or the construction of energy infrastructures for the use of transport (gas pipelines, construction of facilities for alternative energy, charging systems for electric vehicles, etc.) and communications

infrastructures to facilitate the implementation and development of sharing mobility [5] (Santos, 2018). Other transformations have to do with the change in the model of land use. In this case, more sustainable land occupation scenarios should be considered, in which the population's activities require the smallest number of trips by motorized modes [6]. The implementation of sustainable modes requires updating urban planning towards more sustainable scenarios and deploying new approaches to the optimized location of public amenities [7]. Other changes have more to do with transport and mobility governance, such as developing transportation planning policies, plans, and programs oriented toward promoting and regulating sustainable modes. This is where the development of sustainable urban mobility plans (SUMPs) would be located at different geographical scales: national, regional, and municipal. In addition, transport service management systems' transformation towards public models that guarantee environmental justice is required. It is also essential to transform the population's attitude towards the acceptance and preferential use of sustainable modes from the perspectives of environmental, social, and economic improvement and the improvement of health. Finally, it should be noted that the path to a knowledge society has a direct effect on the development of sharing mobility that can help optimize modes of transport management, diversify the offer, and move towards a more sustainable model [8].

The modal choice of transport analysis is a topic of great relevance for a holistic territorial vision on sustainability, since it integrates social, economic, environmental, and governance aspects. Knowledge of the distribution of the modes of transport of the resident population in daily or long-distance trips is key to diagnosing the degree of sustainability of transport in a community. Such knowledge guides planners and managers regarding the types of actions to be carried out in its improvement [9]. There are many factors involved in the modal choice of transport by the population; some have to do with the availability of infrastructures and services. Others are of more of a social nature and are related to the demographic structure, economic activity, or the model of settlement in the territory. The mode choice process is also influenced by psychological and cultural factors that include gender or the motivation for the trip [10,11].

Usually, sustainable modes of transport are related to active and healthy modes (pedestrian or bike). The collective modes of public transport (train, metro, bus) are included equally in the sustainable group, but are not healthy. Environmentally friendly modes are also discussed, preferably referring to sustainable modes [12]. Private motorized vehicles, such as cars, vans, trucks, and motorcycles, are usually included in the group of unsustainable modes, although the use of motorcycles can sometimes be considered sustainable [13]. Electric vehicles are also considered sustainable from the perspective of fossil fuel emissions and consumption, but not for congestion or parking problems. The use of motor vehicles increases fossil fuel consumption and the emission of gases that contribute to the increase in the greenhouse effect and the degradation of air quality that accelerates climate change [14–16].

Mobility plays a fundamental role in the development of tourist destinations [17]. In this sense, it is important to maximize the efficiency of infrastructures, the access to services, and the conditions of intrinsic mobility in a tourist destination. A touristic area that is well endowed, both in infrastructure and transportation services, can increase its competitiveness [18]. In this sense, it is recommended that a tourist destination prioritize sustainable modes [19], as, in addition to assuming an environmental, social, and economic improvement, it constitutes a marketing strategy that provides an image of environmental quality, which constitutes an element of attraction for the tourist [20]. Access to accommodation, tourist resources, and equipment through sustainable modes is a guarantee of quality and has become a priority for planners and tourism managers.

With this approach, the first step towards transport sustainability in tourism zones consists of encouraging the host population to mainly use sustainable modes. This makes the seasonal dynamics of tourism less stressful for transport infrastructure and services, and leads to a reduction in the negative externalities derived from the massive use of private vehicles. In Mediterranean island environments, whose main economic activity is tourism, the negative externalities derived from

unsustainable modes are unacceptable. Road congestion and lack of public transport present a harmful image for tourists, with adverse effects in the medium and long terms [21]. Therefore, the improvement in a tourist destination should not only concern the update of accommodation, leisure, and recreation infrastructure, but also, to a large extent, support mobility infrastructures and services and promote reductions in the use of private vehicles.

In the EU's political framework that promotes territorial development to ensure a model of social and economic cohesion, the massive use of private vehicles in island environments with tourist vocations can unbalance regional economies by jeopardizing the attractiveness of the destinations. In this sense, Mediterranean islands are susceptible to the harmful effects of congestion derived from traffic increases. Therefore, the main objective is for urban mobility to facilitate the economic development of the territory, the quality of life of inhabitants, and the protection of the environment [22]. Therefore, the high sensitivity of tourist destinations to mobility actions advises basing decisions on comprehensive mobility issues.

The hypothesis proposed in this work is that initiatives to promote sustainable mobility should be established and assimilated appropriately by the resident population to set an example for visitors and tourists and to contribute to building a more sustainable tourist destination. Therefore, knowledge of the key factors in the choice of transport modes by the resident population of a tourist destination is essential to diagnose the degree of sustainability of its transport system and deploy an appropriate sustainable mobility policy that includes residents and tourists. Having information on the different modes at the municipal level and knowing the reasons for their choice can help the regional planner base investments in and approaches to sustainable mobility.

To test this hypothesis, an analysis of mobility habits was carried out on the island of Mallorca (Balearics, Spain); its relationship with various social and territorial factors was observed. The study develops a geographic approach and analyzes the relationships between modal selection at the municipal, regional, and island levels.

One of the paper's main contributions to the international literature is the description of a modal choice case study in a mature tourist destination such as Mallorca. In addition, it shows the social inertia that hinders the deployment of sustainable modes and the difficulty of replacing private vehicles if essential infrastructures are not developed. The paper also describes the use of some indicators and specific analysis of mobility data, which can help rationalize investment in transport infrastructure and new facilities' locations.

The paper is structured in four sections: Firstly, an analysis of the scientific literature on the subject of the article is carried out. Then, the methodology includes a description of the case study and the statistical tools used; next, the main results achieved are described and their implications are discussed, and finally, the main conclusions are drawn from the study carried out.

2. Literature Review

The analysis of the factors determining the choice of transport mode is a subject that has aroused great interest in the international scientific community in recent decades. There are many contributions in this area, in which the influence of various factors on modal choice and their relations are detected and analyzed [23]. In the scientific literature, several variables have been identified in this process that can give rise to a multidimensional model in which the following components are distinguished: spatial (physical), social, economic, psychological, cultural, and environmental. Table 1 represents the set of dimensions and factors highlighted by different authors as playing a role in the modal choice process.

Table 1. Dimensions and factors of the modal choice of transport.

DIMENSION/ASPECTS	Transport Mode	Factors	References
The type of trip	Everyone	– Objective of the trip – Time waiting/travel – Distance travelled – Time of the trip – Month of the trip – Complexity of the trip – Possibility of developing activities during the trip – Comfort	[24–26]
The means of transport	Everyone	– Availability of public transportation – Cost of the trip – Discounts – Security – Demand – Independence	[27–30]
Environment	Bicycle Pedestrian	– Climate (temperature, precipitation)	[31–35]
Economy	Private vehicle	– Income level – House size – Car ownership	[36]
Urban design/Built environment Neighborhood spatial patterns	Pedestrian Public transport Private vehicle	– Existence of trees – Size of sidewalks – Mixed uses – Number of intersections of the road network – Urban structure – Density – Diversity – Design – Accessibility	[37–43]
Facilities	Private vehicle Bicycle Pedestrian	– Availability of parking at the destination – Internet availability for the user – Proximity – Dimensions of the facility	[9,40,44–48]
Population structure	Private vehicle	– Gender – Age of the population – Size of family travelling – Number of children/adults travelling – Education level – Nationality of the population	[49–54]
Socio-psychological		– Lifestyle – Perceptions – Attitude preferences – Residential dissonance	[11,55]

Note: For the sake of simplicity, the indicated references have been assigned to one factor, but could include multiple factors.

There is a broad debate about the role played by the more objective factors (environment, physical characteristics) or the more subjective aspects (attitudes or lifestyles) regarding the modal choice [43]. Some authors divide the factors into two groups: macroscopic, referring to characteristics of the environment and society, and microscopic, related to the intrinsic characteristics of the traveler and the attributes of the trip [56].

Regarding the tourists' modal choice, Le-Klähn emphasizes that the main factors of a visitor's/tourist's use of public transport have to do with stopping driving and avoiding congestion or problems when purchasing a private vehicle [20]. Likewise, Lumsdon analyzes the factors that should be considered for bus services designed for tourism, highlighting that the tourist seeks an experiential process rather than a proper displacement [56,57]. Nutsugbodo points out that the availability, safety, and comfort of public transport and sociodemographic characteristics are determining factors in the choice of a tourist destination [18].

In summary, the modal choice is a complex process in terms of the number of influential factors; it is very dynamic and very sensitive to spatial, socioeconomic, and psychological aspects of the type of trip, geographical environment, or people's habits. In this context, some authors have proposed the term mobility as an integrating concept of the set of factors of modal selection [58]. Mobility refers to the potential to be mobile, regardless of whether physical displacement has occurred. This intrinsic complexity implies that the success of proposed modal shifts towards sustainable modes is not a generalizable or straightforward process for any geographical area or target population.

The bibliographic study carried out shows the absence of specific works on the modal choices made by the population living in tourist destinations. This circumstance is not trivial, since these populations receive intense pressure from tourist activity in the high season, which makes them susceptible to negative externalities in terms of mobility. In most cases, the host population experiences an excess of private vehicle use generalizable to tourists (rental), as well as an overload of public transport [59].

In general, in tourist destinations, there is a unanimous agreement (social and political) that sustainable modes need to be developed; however, there is significant resistance to their deployment. These weaknesses are evident in the modal study, as they are the ballast that prevents a correct evolution towards modal sustainability.

Research on mobility in island environments is scarce. However, the problems detected are common to different authors: excessive use of private vehicles, the need for quality public transport, and the importance of public participation in the mobility planning process [60–63].

The use of sustainable mobility indicators is considered a key instrument for developing transport policies at the international, regional, and local levels [64–68]. Indicators have become a tool for monitoring progress towards sustainable development. They are widely used in the framework of sustainable urban mobility plans (SUMPs) [69]. There are numerous proposals for sustainable mobility indicators that refer to different aspects of mobility concerning the main components of sustainability: environmental, social, economic, and governance [9].

One of the most widely used indicators of sustainable mobility concerns the division of modal choice. The percentage of each mode of transport in relation to the total is a primary mobility indicator used in many studies. The modal split (the quantitative relationship between the various modes) provides essential information on the level of sustainability of the geographical area for which it has been analyzed. Some authors propose an indicator for the evaluation of private vehicle reduction [70]. It should be noted that the modal choice is usually integrated within the group of indicators that would refer to observed mobility [71].

3. Methods

3.1. Case Study

Mallorca is the island with the largest surface area (3640 km^2) of the Balearic Islands archipelago, which is located in the Mediterranean basin (Figure 1a). Mallorca, together with the islands of Minorca, Ibiza, and Formentera, is one of the seventeen autonomous communities that make up the Spanish state. The island has 53 municipalities deployed in seven regions or counties (Figure 1c).

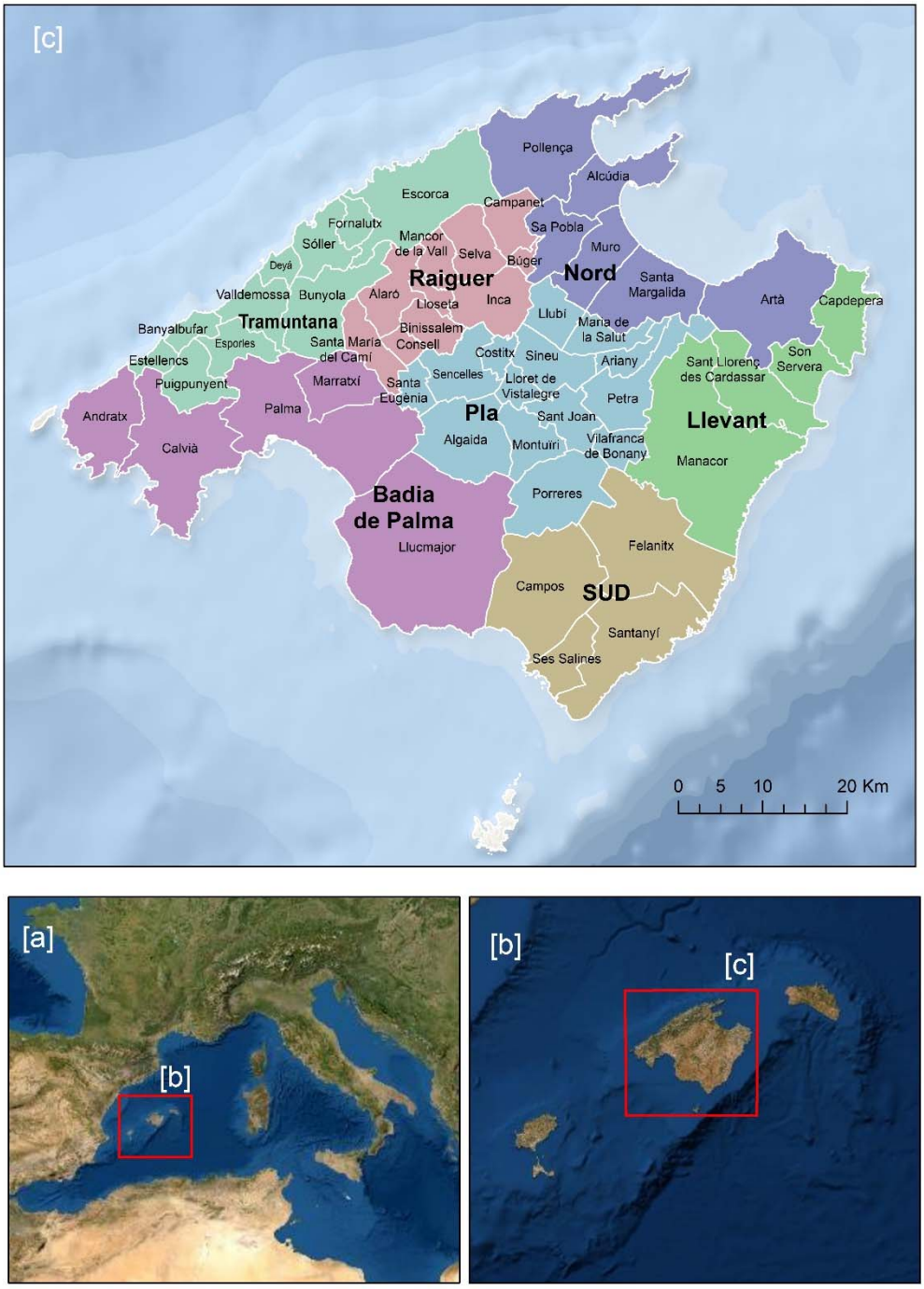

Figure 1. [**a**] Location of Mallorca in the Mediterranean basin, [**b**] location of Mallorca in the Balearic Islands Archipelago, and [**c**] municipalities and counties of Mallorca.

The population of Mallorca amounts to 896,038 people [72] with a heterogeneous territorial distribution. Palma's municipality, the autonomous community's capital, concentrates 48% of its population, followed by the municipalities of Calvia, Manacor, and Inca (Figure 2). The island combines a population model concentrated in traditional centers with a dispersed model of residential constructions on agricultural, rural, or natural land, many of which are used for tourism. This process of diffuse artificialization is known as "rururbanization" [73]. In recent decades, this dynamic has become so widespread that it constitutes a global transformation process, giving rise to an "ISLAND-CITY" model [74] that has crucial consequences on the mobility of its population.

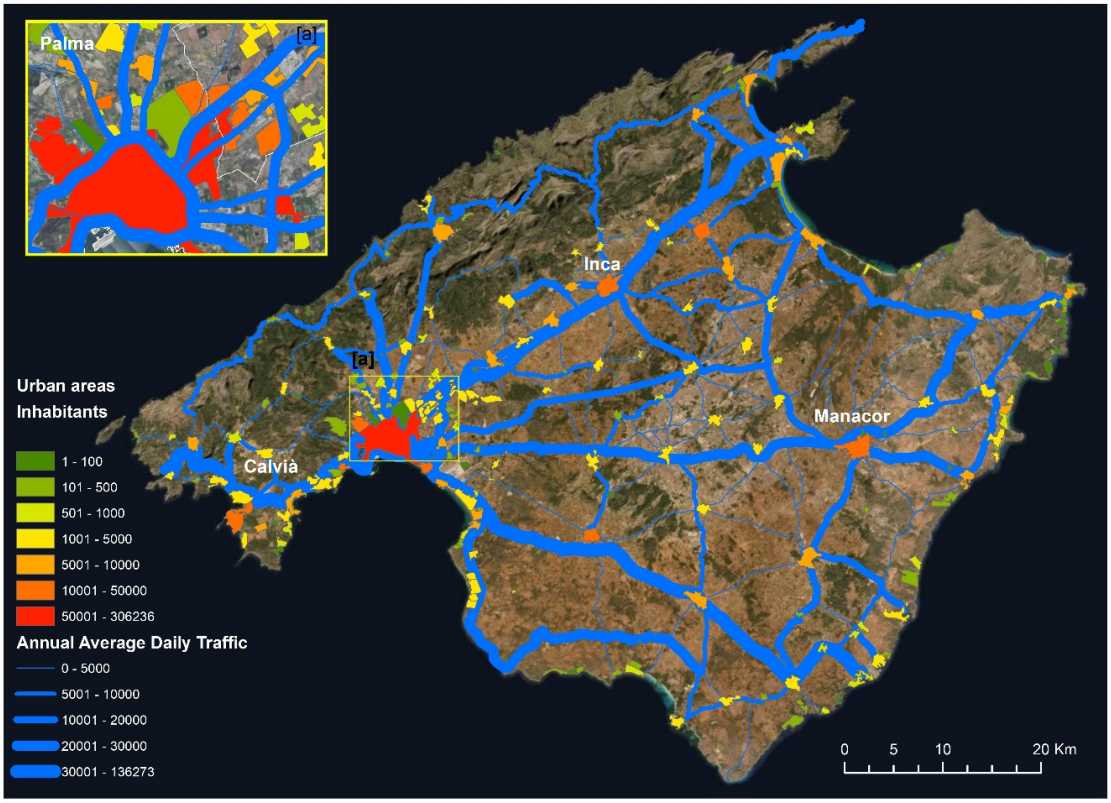

Figure 2. Population in the urban centers of Mallorca and average daily intensity of vehicles on roads. Source: Consell Insular de Mallorca 2020. [75].

The island's population grew by approximately 15% in the period 2005–2019 [72], and the demographic transition model has been established and matured in recent decades. Mallorca's demographic structure shows an intense aging process that is greater in the interior municipalities. The migratory processes are more evident in some centers, especially those that still maintain agricultural activity and receive young immigrants from North Africa and Eastern Europe. However, these movements do not manage to avoid the structural–demographic dynamics of aging.

Most of the island's facilities are located in Palma, which has the most essential transport infrastructure of the island (airport, port), healthcare facilities (hospitals), leading educational facilities (university, schools), commercial and industrial facilities, public administration buildings, etc. This location has a powerful effect on attracting travelers from all over the island to the capital. As a result of this dynamic of mobility, Mallorca's road and train network has always maintained a radial model that links Palma with the rest of the island's municipalities (Figure 3).

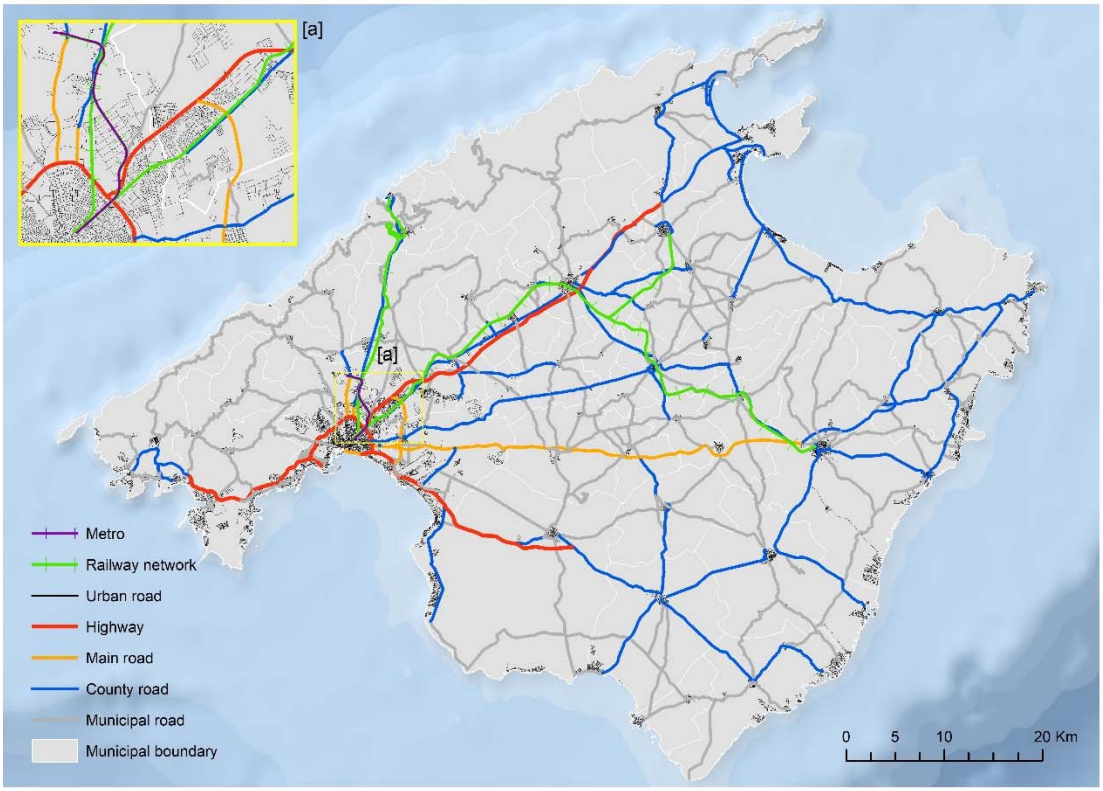

Figure 3. Transport network of Mallorca, [**a**] Detail of Palma city. Source: Consell de Mallorca visor 2020 [76].

The management of island mobility and transport is shared by the Government of the Balearic Islands (GOIB) through the Direcció General de Mobilitat i Transport Terrestre (Conselleria de Mobilitat i Habitatge, GOIB) [77] and the island government of the Consell de Mallorca through the Department of Mobility and Infrastructures [78]. The GOIB manages public transport by road through the Consorci de Transports de Mallorca [79] and the railway and underground through the Serveis Ferroviaris de Mallorca [80]. The Consell de Mallorca is responsible for the regional roads and the traffic of the island. The Palma Town Council manages municipal public transport and infrastructure through its Department of Mobility [81], the Empresa Municipal de Transport (EMT) [82], and the Municipal Parking and Projects Company (SMAP) (http://www.mobipalma.mobi/). Some municipalities have a Sustainable Urban Mobility Plan (SUMP), although at present, they are few (Manacor, Palma, Sóller, Inca, Andratx, Llubí, Capdepera, and Pollença) [83]. The participation of the Palma City Council in the European initiative CIVITAS is noteworthy [84]. It has led to considerable improvement in the public bicycle system, traffic management, a mobility app, the city's parking payment system, the acquisition of a municipal fleet of electric vehicles, and the SUMP of Palma [85].

The regulations on mobility began with the 2004 Law on Land Transport and Sustainable Mobility of the Balearic Islands [86] and culminated in the Balearic Islands Sectorial Mobility Master Plan (2019) [87].

Since the 1960s, Mallorca has based its economy and social development in the tourist industry. In 2019, Mallorca received a total of 11,874,835 tourists (1,597,915 from Spain and 10,276,921 from abroad) [72]. The distribution of the hotels in the island's municipalities is not regular. The coastal municipalities (550 km of coastline) concentrate most of the accommodation, although agrotourism and holiday accommodation are also noteworthy and spread across the interior (Figure 4).

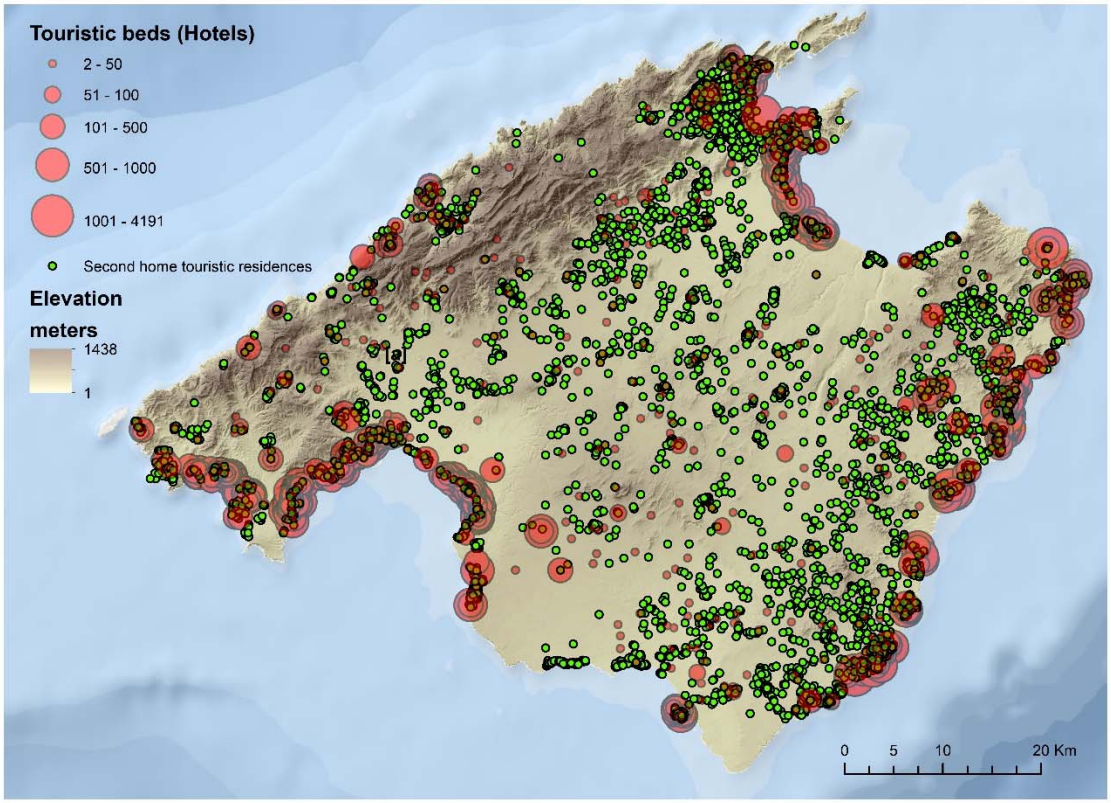

Figure 4. Distribution of hotel equipment in Mallorca on a topographic basis. Source: Govern de les Illes Balears, 2020 [88]; Inside Airbnb (2020) [89].

The topography of the island has a direct influence on the land transport and mobility model. In fact, the mountainous areas, corresponding to the Tramuntana region, are those with the least developed road and rail infrastructure, the smallest population, and the least tourism and economic activity. This means that in this area, the mobility of the resident population is reduced a priori.

At present, the dynamics of population growth, together with the intense development of seasonal tourism, have produced an extraordinary increase in negative externalities derived mainly from private mobility, leading to an increase in traffic and associated problems of congestion and pollution. The average daily intensity of vehicles has experienced continuous growth in recent years. Traffic increased by 42% between 2005 and 2015. The transport model is becoming highly inefficient. Congestion is continuous, especially on roads that serve Palma and the main tourist areas (Figure 2). The large vehicle fleet contributes to this (1136 vehicles/1000 inhabitants in the Balearic Islands and 736 cars/1000 inhabitants in 2020) [90], to which a total of approximately 75,000 rental vehicles must be added that are incorporated into the transport network during the high tourist season in the summer months.

In this geographical framework, it is a priority to deepen our knowledge of the resident population's modal behavior to identify the key factors to guide policies, plans, and projects towards promoting sustainable modes.

3.2. Data Sources

The study used the daily mobility survey corresponding to 2009/2010 from the Government of the Balearic Islands [91]. This survey was undertaken by the Mallorca Transport Consortium under the Balearic Government, and was implemented through telephone interviews (13,905). It was carried out among people over 14 years of age, stratified according to age, gender, and the municipality of residence, in two campaigns between April and June 2009 for Palma and between November 2009

and February 2010 for the rest of the municipalities of the island. The margin of error is ±1.04% for a confidence interval of 95.5%. The survey included questions on the number of trips made the previous day, their origin and destination, the means of transport used, the time of travel, the duration (in minutes) of the trip, the reason, and other data relating to the socio-demographic profiles of the interviewees. The survey results estimate the number of movements made in one working day across the island, broken down by origin and destination, for a total of 53 municipalities. This survey was subsequently expanded with updated demographic information to provide information on the mobility of the resident population at the island level.

For the drafting of the recently approved Sectoral Master Plan for Sustainable Mobility in the Balearic Islands [87], another telephone mobility survey was carried out. This represents an extensive effort recently carried out by the company DOYMO (https://doymo.com/) for the Balearic Islands Government. In this article, it was not possible to obtain the information corresponding to this survey's original data, although its main results were considered.

The data from both sources were compared to obtain more complete information on the mobility situation. Despite the seven-year interval between the two surveys, it can be seen that, a priori, there were no relevant changes in the mobility habits of the population of Mallorca, so the conclusions drawn from the 2009 survey can be reasonably extrapolated to the present day (Table 2). It is essential to point out that 2009 corresponds to a peak moment in the last world economic crisis, which significantly affected the Balearic Islands, and better reflects the island's dynamics as a baseline in terms of mobility.

Table 2. Modal split on Mallorca. Surveys from 2009 and 2017.

			2009	**2017**
	Mode	**Trips**	**%**	**%**
Public	Bus	128,727	5.7%	
	Train	17,401	0.8%	
	Metro	7616	0.3%	
	Cab	6038	0.3%	
	Subtotal	159,788	7.1%	10%
Private	Car	1,214,051	53.4%	
	Motorbike	52,304	2.3%	
	Subtotal	1,266,355	55.7%	55%
Healthy transportation	Bike	30,149	1.3%	2%
	Pedestrian	816,776	35.9%	33%
	Subtotal	846,925	37.2%	35%
Total		2,278,436	100.0%	100%

Source: Conselleria de Territori, Energia i Mobilitat.

Demographic and tourist information was obtained from the National Institute of Statistics (http://ine.es), the Balearic Institute of Statistics [72], and the Government of the Balearic Islands. Finally, information about the traffic flow on the roads of Mallorca was used, which was provided by the Mobility Department of the Consell de Mallorca [78], as well as information about the vehicle fleet published by the General Directorate of Traffic (Ministry of the Interior, Government of Spain) [90].

3.3. Analytic Process

The analysis of the influence of social, economic, and territorial factors on the modal choice and type of travel was made exclusively based on data from the 2009 mobility survey. The phases of analysis are as follows.

3.3.1. Binary Analysis of the Relationship between Modality and Other Variables

Pearson's χ^2 test of independence is used to study whether there is an association between two categorical variables. It is a hypothesis test contrasting qualitative variables. The test supports the null hypothesis, H_o: The variables are independent, so one variable does not vary between the different categories of the other variable; H_a: The variables are dependent, and one variable varies between the different levels of the other variable.

$$\chi^2 = \sum_{i,j} \frac{\left(Observed_{ij} - Expected_{ij}\right)^2}{Expected_{ij}} \quad (1)$$

Each group's expected value is obtained by multiplying the marginal frequencies of the row and column in which the cell is located and dividing by the total number of observations. The differences at all levels are added up. The chi-square distribution has only one parameter, the degrees of freedom, which determines its center and dispersion shape.

$$df = (levels\ variable\ A) - 1\ (levels\ variable\ B - 1) = (columns - 1)\ (rows - 1) \quad (2)$$

The chi-square distribution is positive, so the *p*-value calculation only takes into account the upper tail.

Since the test contrasts whether the variables are related, the effect's size is known as the strength of the association. In our case, we analyze the measures of association of phi or Cramer's V. The limits used for their classification are 0.1 for a small association, 0.3 for a medium association, and 0.5 for a large association. Independence in the sample observations is required.

3.3.2. Integrated Analysis of the Modal Choice

Binary logistic regression was used for the integrated analysis of the modal choice. This statistical technique allows the analysis of the relationship between a dichotomous qualitative dependent variable and one or more independent explanatory variables, or covariates, whether qualitative or quantitative [92]. It is a multivariate predictive regression technique. The basic equation of the binary logistic regression model is exponential, although its logarithmic transformation (logit) allows its use as a linear function. The aim is to model the influence of a set of variables on a dichotomous event's appearance.

In our case, we considered the use of different modes of transport as the dichotomous event. To do so, we transformed a qualitative variable of modes of transportation into a dichotomous variable. The following modes were considered: car, motorbike, bus, metro, pedestrian, bicycle, and sustainable mode, in which all modes were grouped except for car and motorbike.

The logistic regression model makes it possible to quantify the importance of the relationship between the covariates and the dependent variable. First, the interaction between covariates is analyzed concerning the dependent variable (odds ratio). Second, individuals are classified in the dependent variable categories according to the probability they obtain.

It is necessary to ensure that there is no multicollinearity between the predictor variables, so the choice of predictor variables must be made efficiently. The final model should be as small as possible and explain the functional dependencies as much as possible (principle of parsimony).

The covariates' preparation required their corresponding transformation into binary variables (dummy variables), which represent each of the selected categories. Specifically, the following variables are used: sex (a single group is included in which 1 represents men and 0 represents women), age group, occupation, reason for the trip, proximity to Palma of the location of origin, region, and coastal municipality.

The equation of the logistic regression is represented by the natural logarithm of Equation (3):

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k. \quad (3)$$

β_0 and β_k are the coefficients estimated by regression from the data $\beta_0 \beta_k'' X_{1\ldots k}$.

The probability of using sustainable modes of transport may be presented in an equation, as reflected in Equation (4).

$$p = \frac{1}{1 + e^{-Y}} = \frac{1}{1 + e^{-(\beta_0 + X_1 \beta_1 + \ldots + X_k \beta_k)}} \quad (4)$$

The covariates X_1 and X_k are represented by the set of selected variables.

The binary logistic regression considers two events of the phenomenon and is expressed as Equations (5) and (6):

$$\Pr(y = 1) = \frac{1}{1 + e^{-(a+bx)}} = P \quad (5)$$

$$\Pr(y = 0) = 1 - \frac{1}{1 + e^{-(a+bx)}} = 1 - P. \quad (6)$$

The logit transformation arises from considering the probability ratio between two events, called the advantage or ratio (odds). The ratio/odds of an event are the quotient between the probability of it happening and the probability of it not happening (Equation (7)):

$$odds = \frac{P}{1 - P} = \frac{Probability\ of\ P}{Probability\ of\ no\ P} \quad (7)$$

Odds are interpreted as ratios, i.e., the number of times something can happen over something that cannot occur. They are a measure of association between two variables that indicate the strength of the relationship. When the odds ratio is close to 1, there is no association. Values less than 1 indicate a negative association, and values greater than 1 indicate a positive association.

The logistic regression function of the statistical package SPSS version 25 was used for the analysis. The method was configured with the "Enter mode" directly incorporating the whole set of variables selected in the calculation process. This allows us to identify the role played by each variable.

The great utility of logistic regression is to interpret the covariates' effects independently on the dependent variable. This is done by reading the ODDS ratio coefficients (Coef. B, Exp (B)). One of the fundamental problems that arises when several variables are involved in a process is to determine the contribution of each one of them, assuming that the rest of the variables do not change.

3.3.3. Analysis of the Modal Choice at the Municipal Level

In addition to the overall analysis of the factors that influence the modal choice for the island of Mallorca, one of the objectives of this article is to analyze spatial patterns in the modal choice. The modal split distribution of each municipality of Mallorca is assessed, and a new index of sustainable modes of transport is generated (Equation (8)):

$$\text{Sustainable Transport Indicator (ITS)} = \%\ \text{healthy modes (\% Pedestrian + \% Bicycle)} + \%\ \text{Collective modes (\% Bus + \% Metro)}. \quad (8)$$

The ITS index is then normalized as follows (Equation (9)):

$$\text{ITS} = (\text{value} - \min)/(\max - \min). \quad (9)$$

This index makes it possible to establish a hierarchy of municipalities on the basis of the weight that sustainable modes have in each case. The overall analysis of the index facilitates the identification of the areas most dependent on private vehicles as places where sustainable modes should be promoted.

Moreover, using a geographical information system, a database was created that includes territorial information at a municipal level expressed as a total percentage of transport demand (population, tourist places) and the negative externalities of transport (average daily intensity, number of vehicles in the vehicle fleet).

ArcMap 10.5 (Esri©) software was used for the cartographic representation and analysis of geographical data.

4. Results and Discussion

The large figures for the modal split of the residents in Mallorca obtained from the 2009 survey, contrasted with the more recent information from the 2017 mobility survey, show a high dependence on motorized modes for all types of trips (Table 2).

A total of 2.2 million journeys are made daily on the island. This figure has remained unchanged in recent decades.

The pattern of modal choice shows a predominance of the use of private vehicles (55.7%), low use of collective public modes (7.1%), and a moderate level (37.2%) of healthy modes (pedestrian and bicycle). A priori, this distribution shows an evident deficiency in all modes of public transport.

4.1. Modal Relationships

The statistical analysis carried out shows that the modal choice is a multifactorial process in which many variables are involved. The chi-square analysis from contingency tables between the transport modes (qualitative variable: ordinal scale) and various socio-demographic and territorial variables (qualitative variable: ordinal scale) shows significance in the multiple relationships (Table 3):

- Gender and modes: The female population is more likely to use both pedestrian modes (56% female/44% male) and bus transport (61.9% female/38.1% male). Bicycles (35.2% women/64.8% men) and motorbikes (16.5% women/83.5% men), on the other hand, are more commonly used by men. These results show a social model of female segregation, in which women are forced to use public transport rather than private vehicles because they do not have the resources to access their own cars or because of a cultural model in which it is difficult for them to have both a driver's license and their own vehicle.
- Age groups and modes: The private vehicle is typically selected as the preferred mode of transport (55.5% for young people aged 14–29, 62.2% for adults aged 30–44, 51.5% for those aged 45–64), except among the population group over 65, where the pedestrian mode accounts for 61.6% of their journeys. The young population group, from 14 to 29 years old, mostly selects the bus (37.2%), train (39.5%), and metro (53%). The young people's modal choices of bus and metro are related to the segment of the youth population traveling to school. A special case is the metro, which is mainly used by students from the University of the Balearic Islands, who travel to the campus (located 7.5 km away) from Palma by the only metro line available on the island. The group of adults aged between 30 and 44 years has the highest use of private vehicles (40.5%), motorbikes (43.3%), and bicycles (37%).
- Travel time and modes: Ninety-one percent of trips in Mallorca are local, not exceeding 30 min by car. This interval of travel time corresponds to 83% of trips by train, 80.8% of trips by metro, 93% of trips by car, 98.2% of trips by motorbike, 84.5% of trips by bicycle, and 92.4% of trips by foot. Trips of 30 to 60 min account for 7.6% of the total. Train use is predominant at this interval. Most of the movements around the island comprise recurrent journeys close to the city of Palma from peripheral municipalities, while there are also journeys between inland municipalities and nearby coastal areas. In the interval of trips lasting over 60 min, movements are mostly made on

foot or by car (with these modes accounting for 62.6% of trips lasting from 60 to 90 min, 59.2% of trips lasting from 90–120 min, and 64.3% of trips lasting over 120 min).

- Proximity to Palma and modes: In total, 54.8% of trips are concentrated in areas less than 15 km from Palma. In addition, 22.53% of train trips are made in areas between 30 and 50 km from Palma, corresponding mainly to movements in Inca and Manacor. These results confirm a radial model of movements to and from Palma as a unique center of attraction and trip generation.
- Regions and modes: The Badia de Palma region concentrates the largest number of journeys (62.9%) in Mallorca. It is worth noting that 95% of all bus journeys and 100% of all trips by metro are made in the Badia de Palma area. The majority of train use is in the Badia de Palma region (56.2%) and in the Raiguer region (23.5%). This distribution shows the great reputation of the city of Palma and its surrounding municipalities (Marratxí, Calvià, Llucmajor) as areas that generate and attract journeys.
- Motive for the journey and modes: Home travel (53.2%), personal arrangements (20.4%), and access to work (16.8%) are the main reasons for travelling. Some 18.1% of bus journeys are made for work purposes. The majority of trips are for traveling home (58.9%) and personal management (24.5%). It should be noted that people preferably start their journeys from their homes in private vehicles and use this mode for almost all their movements.
- Occupation and travel modes: Active people who are employed mainly use cars for their journeys (64.3%), and students also use private vehicles (45.5%). Of the total number of metro users, 49.6% are students. The retired population has reduced use of motorized modes and concentrates 58.9% of their mobility on pedestrian journeys. The bus is used mostly by the working population (37.9%) and students (23.8%).

Table 3. Chi-square values of Cramer's factor V and significance coefficients obtained from the derivation of contingency tables between modes of transport and different variables.

	Pearson Chi-Square	**df**	**Cramer's V**
Gender (Categories: men/women)	47,808.306 *	7	0.145 *
Age groups (Categories: 14–29/30/44/45/64, +64)	144,839.779 *	21	0.146 *
Activity (Categories: working, retired, student, unemployed, domestic work, other)	217,340.395 *	35	0.139 *
Trip motivation (Categories: leisure, work, doctor, study, mixed, home)	99,176.263 *	35	0.100 *
Travel time (0–30/30–60/60–90/90–120 min)	126,206.872 *	28	0.118 *
County of origin (Categories: Badia Palma, Llevant, Nord, South, Raiguer, Pla, Tramuntana)	81,004.755 *	42	0.077 *
Distance to Palma	87,084.148 *	21	0.113 *
Coastal (coastal/non-coastal)	31,424.402 *	7	0.118 *

(*) Significant at 0.99 for Sig values < 0.01.

The low degree of randomness of the set of relations analyzed is noted (Table 2). The significance of all the chi-square tests is relevant, so the null hypothesis must be rejected. Despite this, the factors analyzed do not provide high Cramer's values in general, so the modal choice's multifactorial character is evident. The variables with the greatest relation to the selection of modes are gender, age group,

and people's activity. Second, the reason for the trip and its duration are highlighted. The region of origin of the journey is less related to the modes.

4.2. Factors in Modal Selection

The travel time variable was eliminated from all the analyses because it has no significance.

4.2.1. Motorized Modes

Table 4 shows the results of the logistic regression using private vehicles as the dependent variable. We can observe that almost all the variables considered play a significant role in predicting the use of private vehicles (significance < 0.00). No variable was extracted from the process.

Table 4. Results of the logistic regression of private vehicles.

	CAR		MOTORBIKE	
	B	**Exp (B)**	**B**	**Exp (B)**
Man	0.352 *	1.422	1.560 *	4.758
14–29 years	0.848 *	2.335	1.153 *	3.167
30–44 years	0.963 *	2.620	1.223 *	3.396
45–64 years	0.600 *	1.822	0.753 *	2.123
Working	0.326 *	1.386	−0.517 *	0.596
Retired	−0.433 *	0.649	−0.926 *	0.396
Student	−1,182 *	0.307	−0.248 *	0.780
Unemployed	−0.215 *	0.807	−0.752 *	0.471
Other	−0.256 *	0.774	−0.138 *	0.871
Domestic work	−0.236 *	0.790	−1.878 *	0.153
Leisure	0.893 *	2.443	0.128 *	1.137
Work	0.960 *	2.611	0.329 *	1.390
Doctor	0.934 *	2.545	−0.642 *	0.526
Study	0.675 *	1.964	−0.419 *	0.658
Mixed activities	0.841 *	2.318	−0.234 *	0.791
Home	0.662 *	1.939	0.051 *	1.052
Badia de Palma	0.625 *	1.869	−1.260 *	0.284
Llevant	0.829 *	2.291	−1.549 *	0.212
Nord	0.778 *	2.178	−1.327 *	0.265
South	0.910 *	2.484	−1.831 *	0.160
Raiguer	0.086 *	1.090	−1.196 *	0.302
Pla	0.206 *	1.228	−0.611 *	0.543
0–30 min	0.934 *	2.546	0.677 *	1.968
30–60 min	0.626 *	1.869	−0.688 *	0.502
60–90 min	0.385 *	1.470	−0.244 *	0.784
90–120 min	0.184 *	1.202	−0.425 *	0.654
Non-coastal	0.345 *	1.413	−1.044 *	0.352
Constant	−2.496 *	0.082	−3.742 *	0.020

(*) Significant at 0.99 for p-value < 0.01.

First, it should be noted that men, in general, have a positive tendency to use private vehicles compared to other modes (Car: B = 0.352, Exp (B) = 1.422; Motorcycle: B = 1.56, Exp (B) = 4.75). This result is relatively common in Spain's mobility and gender studies [93,94]. Women have a type of dependent mobility. This indicator reflects that the society is not very advanced in terms of gender and that there is a social pattern of women's dependency on men.

Concerning the analysis by age group, the majority use of private vehicles by the adult population (30–44 years) is significant (Car: B = 0.352, Exp (B) = 1.422; Motorcycle: B = 1.56, Exp (B) = 4.75), and there is a radical reduction in the use of these vehicles by the elderly. This circumstance confirms the adult population's purchasing power for the acquisition of a private vehicle and its majority use in daily mobility. From this perspective, the demographic dynamics of aging in the coming years could lead to a significant decrease in the young population, especially in the more rural municipalities in the island's interior, which would have a direct effect on reducing the use of private vehicles.

People's work activity also affects their modal choice. People who are working make the most use of private vehicles, while students and retired people seem least inclined to choose cars as their means of transport.

We want to emphasize the positive sign of the B coefficients for all the reasons for the trip. This indicates the high social orientation towards the use of private vehicles. Regarding the reason for the trip, the use of private vehicles for trips to work (Car: B = 0.960; Exp (B) = 2.61) and to health centers (Car: B = 0.934; Exp (B) = 2.54) is prominent. This is because public reference hospitals do not have an efficient transport service in terms of frequency or accessibility to all locations on the island. For this reason, the use of private vehicles is required for these types of trips. This factor shows a high level of inequity in the island's transport service to the facilities. The travel motive for leisure also appears to be differentiated. Therefore, in many cases, these are journeys to urban centers and natural areas.

In terms of the territorial analysis carried out, Mallorca's southern region stands out as being highly dependent on private vehicles (B = 0.91; Exp (B) = 2.48). This tendency is reproduced in the rest of the regions of the island with more or less significant intensity. However, the Raiguer region appears with a very low B coefficient (B = 0.086) and little relevance (Exp (B) = 1.09). It is also important to note that the Serra de Tramuntana region does not appear relevant.

The proximity to the city of Palma is also a factor that increases the use of private vehicles. The residents in the areas closest to the capital are also those who use private vehicles most often. This fact reveals the structural unsustainability of the city of Palma's efforts to encourage the use of alternative modes.

Finally, it can be seen that inland areas of the island (not along the coast) are also more dependent on private vehicles for their journeys.

4.2.2. Collective Modes: Bus, Train, and Metro

The bus and train collective modes are used mostly by women (Bus: B = −0.53 Exp(B) = 0.58). Students use the bus more often (B = 0.318, Exp(B) = 1.374) than other groups (Table 5). Bus trips for medical visits (B = 1383, Exp(B) = 3.98) are particularly noteworthy, followed by work activities (B = 0.826, Exp(B) = 2.28) and access to educational centers (B = 0.816, Exp(B) = 2.26). The coefficients of significance for the use of the train eliminate two age groups (20–44 and 45–64 years) and the variables that refer to the activity carried out by the people. The use of the train by the youngest group (14–29 years old) for any activity in general, but particularly for study, leisure, and work, is remarkable. Access to the railway infrastructure reflects the fact that the Raiguer region is the most privileged (B = 3.653, Exp(B) = 38.59, followed by Pla (B = 2.94, Exp(B) = 19). Journeys by train tend to be between 0 and 15 min from Palma (B = 2.55, Exp(B) = 12.84).

Table 5. Results of logistic regression for collective vehicles.

	BUS		TRAIN		METRO	
	B	**Exp (B)**	**B**	**Exp (B)**	**B**	**Exp (B)**
Man	−0.537 *	0.585	−0.284 *	0.753	0.024	1.024
14–29 years	0.076 *	1.079	0.474 *	1.606	−0.956 *	0.385
30–44 years	−0.207 *	0.813	0.001	1.001	−0.424 *	0.654
45–64 years	0.077 *	1.080	−0.004	0.996	−0.209	0.811
Working	−0.763 *	0.466	15.959	-	1.778	-
Retired	−0.287 *	0.751	16.407	-	14.824	-
Student	0.318 *	1.374	16.667	-	17.858	-
Unemployed	−0.313 *	0.731	16.079	-	14.311	-
Other	−0.115 *	0.892	14.462	-	11.13	3.044
Domestic work	−0.523 *	0.593	16.445	-	13.740	-
Leisure	0.302 *	1.353	1.409 *	4.093	0.449 *	1.566
Work	0.826 *	2.284	1.226 *	3.408	1.544 *	4.685
Doctor	1383 *	3.988	1.088 *	2.968	−13.764	0.000
Study	0.816 *	2.261	1.249 *	3.486	1.879 *	6.545
Mixed activities	0.101 *	1.106	0.307 *	1.359	0.906 *	2.473
Home	0.327 *	1.386	0.894 *	2.446	0.871 *	2.390
Badia de Palma	−0.274 *	0.760	−1.060 *	0.346	−0.949 *	0.387
Llevant	−2.801 *	0.061	1.809 *	6.107	−5.102	0.006
Nord	−2.253 *	0.105	0.693 *	2.001	−16.491	0.000
South	−1.559 *	0.210	−1.752 *	0.173	−14.906	0.000
Raiguer	−0.419 *	0.658	3.653 *	38.591	−5.002 *	0.007
Pla	−0.236 *	0.790	2.945 *	19.009	−3.623 *	0.027
0–30 min	−2.122 *	0.120	2.553 *	12.849	−4.534 *	0.011
30–60 min	−1.750 *	0.174	−2.141 *	0.117	−2.652 *	0.070
60–90 min	−1.867 *	0.155	−2.040 *	0.130	−0.741 *	0.477
90–120 min	−0.479 *	0.620	−2.741 *	0.064	−11.630	0.000
Non-coastal	−0.246 *	0.782	−1.216 *	0.297	1.710 *	5527
Constant	−1.635 *	0.195	−21.013	0.000	−20.732	0.000

(*) Significant at 0.99 for p-value < 0.01.

Concerning the use of the metro, the most important conditions are its preferential use for access to the educational centers (University of the Balearic Islands) (B = 1.87, Exp(B) = 6.54) and the work centers (B = 1.54, Exp(B) = 4.68).

4.2.3. Healthy or Active Modes

The reasons affecting the choice of healthy modes are multiple (Table 6). However, those that have the greatest significance are the following: The pedestrian mode is used preferentially by women, retired persons (B = 0.879, Exp(B) = 2.4), unemployed persons (B = 0.7, Exp(B) = 2.013), and those engaged in domestic work (B = 0.69, Exp(B) = 2). Likewise, the most relevant journeys on foot exceed 90 min. The use of the bicycle is preferable for men (B = 0.6, Exp(B) = 1.83), for trips to work (Exp(B) = 1.4) and to study centers (Exp(B) = 1.25), and for journeys lasting 60 to 90 min.

Table 6. Results of the logistic regression of healthy or active modes.

	PEDESTRIAN		BIKE	
	B	**Exp (B)**	**B**	**Exp (B)**
Man	−0.303 *	0.738	0.606 *	1.833
14–29 years	−0.903 *	0.406	0.108 *	1.114
30–44 years	−0.776 *	0.460	0.041	1.041
45–64 years	−0.408 *	0.665	−0.103 *	0.902
Working	0.167 *	1.181	0.355 *	1.426
Retired	0.879 *	2.408	−0.185 *	0.831
Student	0.598 *	1.818	0.229 *	1.258
Unemployed	0.700 *	2.013	0.041	1.042
Other	0.301 *	1.351	0.496 *	1.641
Domestic work	0.695 *	2.004	0.197 *	1.217
Leisure	−1.113 *	0.329	0.035	1.036
Work	−1.234 *	0.291	−0.287 *	0.750
Doctor	−1.871 *	0.154	−2.097 *	0.123
Study	−1..034 *	0.355	−0.530 *	0.588
Mixed activities	−0.649 *	0.523	−0.625 *	0.535
Home	−0.668 *	0.513	−0.243 *	0.784
Badia de Palma	−0.546 *	0.579	−0.266 *	0.766
Llevant	−0.512 *	0.600	0.468 *	1.597
Nord	−0.455 *	0.634	0.566 *	1.761
South	−0.668 *	0.513	1.082 *	2.950
Raiguer	0.064 *	1,066	−1.394 *	0.248
Pla	−0.109 *	0.897	−0.537 *	0.584
0–30 min	−0.843 *	0.430	−1.680 *	0.186
30–60 min	−0.181 *	0.834	0.090 *	1.094
60–90 min	−0.058 *	0.944	0.629 *	1.876
90–120 min	0.115 *	1.122	−0.629 *	0.533
Non-coastal	−0.349 *	0.706	0.645 *	1.906
Constant	0.921 *	2.512	−4.603 *	0.010

(*) Significant at 0.99 for p-value < 0.01.

4.2.4. Sustainable Modes

An analysis of the factors involved in the modal choice of sustainable modes (bus, train, metro, pedestrian, and bicycle) shows that all the factors considered have some significance, although few stand out in a special way (Table 7). Remarkably, the sustainable modes are chosen by women, especially among retired adults, students, and the unemployed. These modes are rarely selected for travel to work, leisure, or medical facilities. Sustainable methods are used more in the Raiguer region than in other regions. In general, the analysis reflects that compared to private vehicles, the sustainable modes represent a small fraction for all groups and all travel reasons.

Table 7. Results of the logistic regression of sustainable modes.

	B	Exp (B)
Man	−0.374 *	0.688
14–29 years	−0.852 *	0.427
30–44 years	−0.806 *	0.447
45–64 years	−0.427 *	0.653
Working	−0.136 *	0.873
Retired	0.650 *	1.915
Student	0.635 *	1.886
Unemployed	0.428 *	1.534
Other	0.136 *	1.146
Domestic work	0.404 *	1.498
Leisure	−0.978 *	0.376
Work	−0.936 *	0.392
Doctor	−1200 *	0.301
Study	−0.631 *	0.532
Mixed activities	−0.658 *	0.518
Home	−0.597 *	0.550
Badia de Palma	−0.609 *	0.544
Llevant	−0.699 *	0.497
Nord	−0.649 *	0.522
South	−0.781 *	0.458
Raiguer	0.028 *	1.028
Pla	−0.106 *	0.900
0–30 min	−1.066 *	0.345
30–60 min	−0.569 *	0.566
60–90 min	−0.380 *	0.684
90–120 min	−0.209 *	0.811
Non-coastal	−0.388 *	0.678
Constant	1.751 *	5.763

(*) Significant at 0.99 for p-value < 0.01.

4.3. Modal Choice at the Municipal Level

The analysis of the modal choice's geographical distribution allows the identification of significant differences at the municipal and regional levels. Some of the results obtained in this section could be reviewed more generically in the previous section when reference was made to the "Region" variable. Significant patterns could be detected about the regions of origin of the movements concerning the population's use of the different modes.

Figure 5 shows the number of journeys in different modes at the municipal level and the percentage of each mode's use. In the case of the use of private vehicles, a massive generation of journeys can be observed from the populated areas of the municipalities of Badia de Palma (Calvià, Palma, Llucmajor, and Marratxí). Noteworthy cities include Inca in the island's center, Pollença and Alcúdia in the north, and Manacor, Felanitx, and Capdepera in the east. The map shows the island's population distribution model, maintaining the relationship between the number of movements and population

density. Certain inland areas of the island (Pla de Mallorca) and the Serra de Tramuntana present the lowest number of journeys. The map of percentages of trips by car (5a′) shows the main dependence on private vehicles for municipalities such as Calvià and Marratxí (Badia de Palma), Capdepera (Llevant), Ariany (Pla), and Escorca (Serra Tramuntana). There are clear patterns of dependence on private vehicles. These are zones in which collective sustainable modes are not accessible, and sustainable mobility must be promoted through investment to improve infrastructure and services.

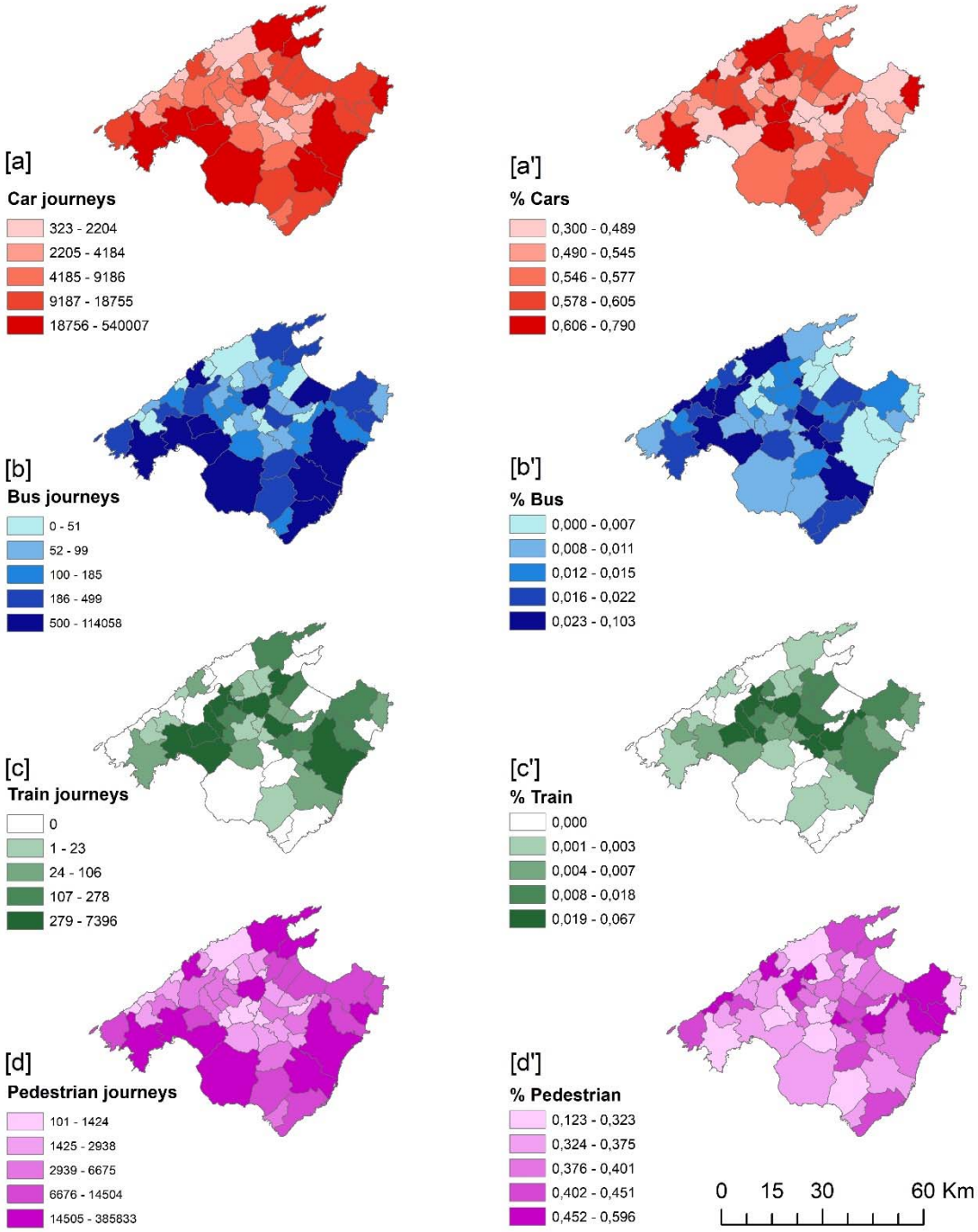

Figure 5. Municipal modal distribution. Number and percentage of movements by mode.

Bus transport at the municipal level, in terms of the number of trips, also reveals a pattern closely related to the distribution of the population (Figure 5b). The percentage distribution of journeys highlights Palma, mainly because it has a municipal bus service (the EMT). The areas without rail

infrastructure force people who do not have a private vehicle to use public buses (Figure 5b'). This is a geographical distribution model that highlights the peripheral municipalities of the main centers of travel attraction on the island (Palma, Inca, Manacor).

The distribution of train journeys shows the routes of Mallorca's rail networks (Figure 5c,c'). The municipalities in the Raiguer region obtain the highest values both in absolute figures for the number of journeys and in percentages of preferential use of the railway. The presence of large areas of the Serra de Tramuntana and in the south of Mallorca (Llucmajor, Santanyí, Ses Salines) without railway service is evident.

Pedestrian mobility is more common in municipalities that suffer from certain isolation from collective modes (bus, train). The municipalities of Sóller, Andratx, Estellenç, and Puigpunyent in the Serra de Tramuntana and the municipalities in the eastern (Artà, Son Servera, Sant Llorenç) and the southern parts of Mallorca (Santanyí) are worthy of note. It has been demonstrated that the obligation of having a vehicle for travel motivates pedestrian mobility within the municipalities. Therefore, this represents a factor of isolation, rather than a preference for sustainable modes.

The municipal distribution of sustainable modes (Figure 6) shows a very irregular pattern. On the one hand, there are areas with low values for the use of sustainable modes in municipalities very close to Palma (Calvià, Marratxí, Algaida, Sencelles). They present a model of a dormitory town in which private vehicles are preferred. There are also areas in the Serra de Tramuntana (Escorca, Selva, Deià) whose mobility is highly restricted to cars due to the lack of access to other modes. Capdepera and Ariany also stand out in eastern Mallorca due to their clearly isolated situation. The municipalities that are most highly rated in terms of the use of sustainable modes are also scattered. There are municipalities with a small population, generally older, in which the majority of trips are made on foot within the town itself (Pla), and they have railway stops (Binissalem). The municipalities with an economic sector that encourages travel within the municipality without the need to move for work or professional reasons also obtain high values (Sóller, Artà, Santanyí).

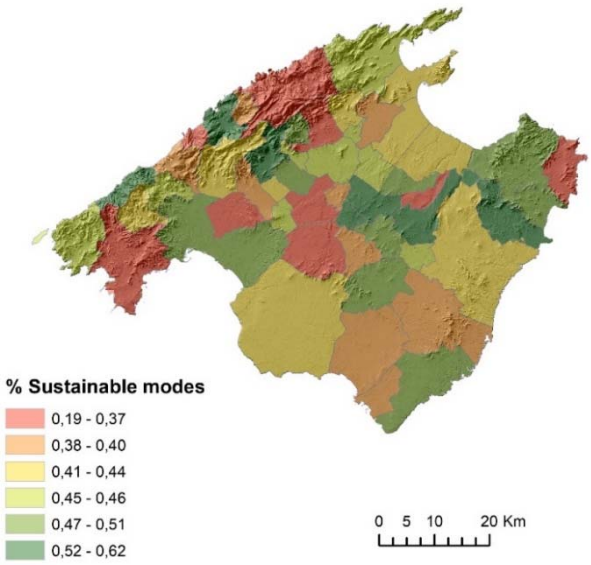

Figure 6. Municipal distribution of sustainable modes (bus, train, metro, pedestrian, and bike modes).

Figure 7 provides an integrated view of the municipal distribution of three key factors of mobility: percentage of transport demand (population + tourist places), rate of use of sustainable modes (bus, train, metro, pedestrian, bicycle), and the percentage of negative externalities derived from the use of private vehicles (average vehicle intensity at the municipal level + mobile vehicle park). It can be shown that demand and impacts, in general, maintain a high correlation (Pearson's correlation coefficient 0.84; p-value < 0.01). In other words, in general, the higher the population and tourist activity of the municipality, the higher its level of traffic and congestion. However, there are municipalities that,

although their demand for transport is essential, do not show very significant negative externalities of traffic (Alcúdia, Calvià, Capdepera, Sant Llorenç, Santa Margalida, Santanyí, Son Servera). The opposite is also true, where small towns with low demand suffer from significant negative externalities from the traffic on the roads that pass through them (Marratxí, Algaida, Andratx, Ariany, Búger, Binissalem, Inca, Sencelles, Vilafranca, etc.).

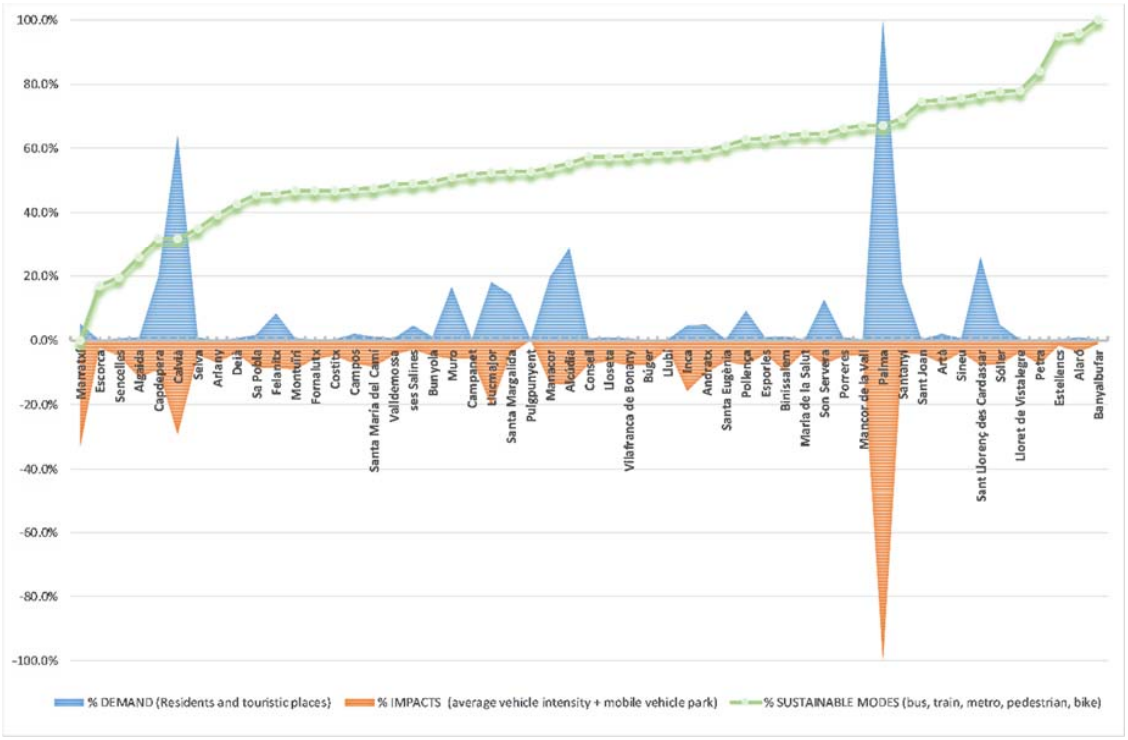

Figure 7. Municipal distribution of % transport demand, % impacts of transport, and % sustainable transport modes.

It is shown that the percentage distribution of the use of sustainable transport at the municipal level has no relationship with the demand for transport or negative externalities. The selection of sustainable modes seems to be influenced by other factors that, as we saw above, are related to variables concerning access to infrastructure and social variables specific to each municipality, the topography, or the municipal location itself. This shows that each municipality has specific dynamics, so municipal classification does not provide a global vision of the island's dynamics.

Figure 8 shows the movements from a municipality of origin to the rest of the municipalities. The maps show the mobility pattern of journeys. From each municipality of origin, an area of concentric influence is reproduced, which makes journeys to the nearest municipalities more likely. Palma's municipality appears on all the maps, which corroborates its role as the capital of the island and as an attraction for trips from the rest of the island. The zoning generated by the tourist destinations of Alcúdia (North), Capdepera (East), and the influential areas of Inca and Manacor are well visualized.

A total of 78.5% of journeys are made within the same municipality (Table 8). Of the total number of journeys in private vehicles on the island, 64% are made in the same municipality. These figures show that actions to improve mobility targeted explicitly at the municipal level could significantly improve the path to sustainable mobility. This circumstance gives great importance to municipal sustainable urban mobility plans as critical instruments for redirecting transport to sustainable modes, and advises that they be developed in all municipalities and tourist areas.

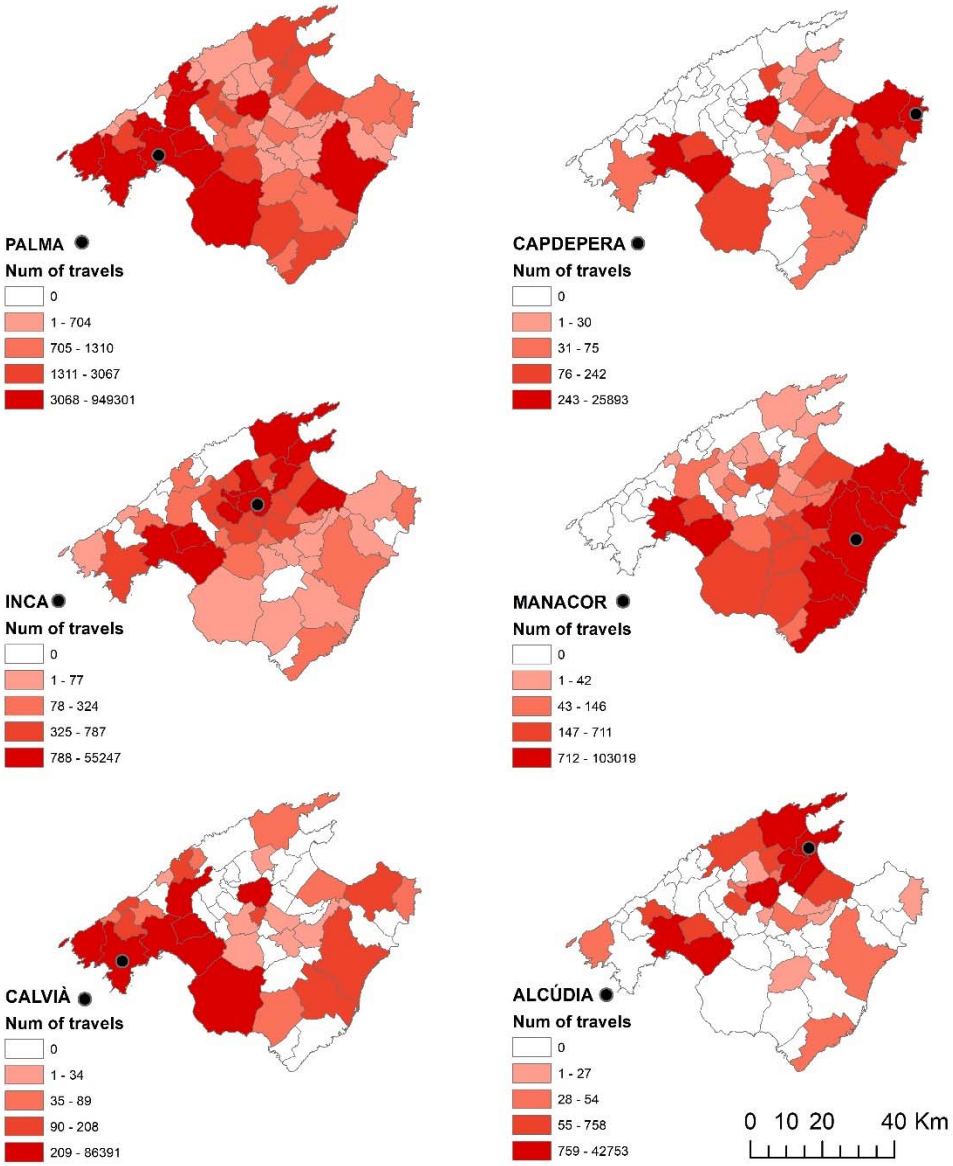

Figure 8. Mobility patterns from the main municipalities. Number of trips from the municipality of origin.

Table 8. Displacements made in the same municipality.

	Mode	% Trips in the Same Municipality
Public	Bus	88.1%
	Train	0.6%
	Metro	82.7%
	Cab	82.0%
Private	Car	64.0%
	Motorbike	87.6%
Healthy transportation	Bike	92.8%
	Pedestrian	99.0%
Total modes		78.5%

The first key issue that was highlighted in this study is the absolute dependence on private vehicles in the daily mobility of residents in Mallorca. Among the leading causes of this are the following:

- Road transport infrastructures are predominant in the island territory, and these roads determine the destinations and their flows. Despite a collective awareness of the promotion of sustainable modes, Mallorca does not have sufficient infrastructure to give proper support to this model. In particular, the rail network is minimal and very poor, as are the metro lines, which are found only in the city of Palma; nor is there any infrastructure for electric trams in urban or peri-urban areas, which could reduce the dependence on cars. The use of railways in certain municipalities in the Raiguer region is significant. Therefore, it is demonstrated that where rail infrastructures exist, their use is also normalized.
- The development of the tourist model in the 1960s was carried out in parallel with the development of motorization, consolidating private transport's predominance and the lack of concern for collective public modes of transport on the part of the authorities.
- The population pattern in Mallorca is seasonal, making the development and maintenance of efficient and sustainable public transport services complex and costly. Most of the connections among population centers are radial through Palma, a historical territorial heritage, so transversal accessibility on the island is not always guaranteed. The areas of new construction are consolidated in territories without transport services, so the use of private vehicles is obligatory for many journeys.
- The dynamics of mobility promoted by seasonal tourism attract workers living in inland areas to coastal areas. This generates a continuous flow of journeys, which increase traffic congestion at the access points to tourist areas. The implementation of holiday homes (Airbnb) in urban and rural areas has added to the pressure on private vehicle transport.
- The size of the island (maximum 100 km) makes it feasible, a priori, to travel by car to all zones in a short time, making the private vehicle the preferred mode of transport for the population. Most journeys (91.7%) do not exceed 30 min. This makes it an aspiration for all inhabitants to have a private vehicle regardless of the externalities it generates.
- The capital, Palma, has the largest population and concentrates the most important infrastructures, equipment, and services of the island. Therefore, it is a unique center of attraction and trip emission. One example is the University of the Balearic Islands, located 7.5 km from Palma, which generates the mobility of a university group that exceeds 15,000 people, and 62.4% of journeys are made by car. This territorial polarization causes imbalances in mobility on an island level that are difficult to resolve.
- The topography of Mallorca makes it difficult to develop sustainable transport infrastructures (railway networks), especially in the Serra de Tramuntana regions. This entails a greater dependence on private vehicles for the residents of this area.

One of the consequences of functional dependence on private vehicles is a social gap of imbalance, equity, and lack of spatial justice, especially in disfavored groups. These groups include the immigrant population without resources, the female population, children, and the elderly. These groups make the most use of (sustainable) collective transport modes. However, we understand that the choice of sustainable collective modes is made in many cases not by choice, but because of the lack of access to the use of private vehicles.

The negative externalities caused by the use of private vehicles, especially congestion and pollution, motivate changes in the mobility habits of residents who are more committed to using sustainable modes, as seen in the evolution of the modal distribution between the surveys in 2009 and 2017. Therefore, we perceive a state of forced dissonance in the selected modes of transport by the resident population [55,95]. The dissonance is between the population's preference for using a mode and its relation to the mode used in practice. The explanation is that there is no possibility for the preferred use of sustainable modes because there are no appropriate infrastructures or services for the citizen,

so forced mobility is condemned to be carried out in private vehicles. The dissonance is also of a residential nature because sites are selected for living that do not have efficient public transport, which requires the use of a private vehicle for any type of journey.

The results regarding the modal distribution and inter-municipal mobility show the existence of a generalized pattern of radial mobility towards Palma from all points of the island and the development of sub-graphs of mobility from/to the main population centers (Inca, Manacor, Calvià, Alcudia, etc.). For this reason, island mobility must be understood in a holistic way. This is the vision that the public administration has taken into consideration over the last few years and has been reflected in the Balearic Islands Mobility Sectorial Master Plan 2019–2026 [88]. The following objectives are prioritized in this plan:

- Guaranteeing access to public transport, especially for vulnerable groups;
- Reducing pollution generated by mobility;
- Reducing accidents;
- Minimizing energy consumption;
- Minimizing the minimum distance of journeys;
- Changing the modal distribution in favor of non-motorized collective modes;
- Making public transport more flexible and giving rigidity to the private transport offer;
- Optimizing the connections between islands.

Despite the fact that these objectives' fulfillment will mean a significant advance in mobility, we consider that there is still much work to be done. In particular, sustainable mobility development requires greater coordination between the various sectoral island plans, regarding not only mobility and infrastructure, but also urban and tourism planning. Likewise, for the development of sustainable modes of transport, it will be necessary to focus on the promotion of sustainable built environments [96] that promote sustainable modes of transport. Furthermore, municipal mobility plans are still embryonic and require comprehensive coordination with other plans.

A major risk is promoting sustainable modes based on the use of electric, gas, or other fuel vehicles. This is because one of the main problems generated by mobility in Mallorca is related to congestion (roads, parking). Therefore, the emphasis of the island and municipal plans should be to promote non-motorized modes (train, underground, tram, bicycle, pedestrian, etc.).

The possibility of having efficient sustainable modes of transport is a determining factor in the choice of tourist destination and represents an important environmental incentive. The design of transport investment strategies that maximize the social and economic return on investment should be encouraged, especially in island regions. A commitment to the construction of road transport infrastructure with a high territorial impact can have negative consequences on the tourist destination. It is advisable to commit to the development of sustainable modes [97] and to monitor the sustainability of proposed transport and mobility projects [4,97].

The challenges for the promotion of sustainable mobility in Mallorca must be addressed considering both residents and tourists. It would be important to deploy economic tools, communication, or physical actions regarding the population and tourism [98,99]. The implementation of shared mobility instruments would also be of interest, especially if electric vehicles were promoted [5,100]. It is considered necessary to develop business synergy between the tourism industry and mobility companies and to promote innovative mobility actions for both residents and tourists that would lead Mallorca towards a model of sustainability, as other tourist destinations have developed [101]. On this road to sustainable mobility, initiatives should be developed that take advantage of the widespread use of social networks and apps among both residents and tourists, which could have great applicability [102].

5. Conclusions

The modal choice of transport on the island of Mallorca depends on a wide range of factors, such as gender, age group, the motive for the trip, activity, region of residence, duration of the trip, or proximity to Palma, the capital of the island. The private vehicle is the primary mode. Its use is preferred by working men aged 30–44, and it is used for journeys to the home and to work that do not exceed 30 min, preferably in areas close to Palma. The motorbike is also an essential mode for men of the same age for work purposes. Women's trips, in general, incorporate more collective and healthy modes. Women, young students, and retired people are the main users of buses for access to school, medical visits, or work activities. Trains are used extensively for trips lasting less than 30 min, especially in the municipalities of the Raiguer region. The metro in Palma provides young students access to the university. Sustainable modes are not widely adopted, and women, young people, and retired people are the main groups that use them.

The municipalities included in the Badia de Palma region, the metropolitan area, generate the most significant number of journeys. Additionally, the centers of Inca, Manacor, Calvià, Alcúdia, and Capdepera stand out as areas that generate and attract trips at a regional level.

The scarce deployment of rail and metro infrastructures limits the use of these modes to a minimum. The most isolated areas of Mallorca, with an aging population, are highly dependent on public transport, which can generate imbalances and inequalities in access to health and educational facilities.

The demand for transport generated by the resident population and tourist activity as well as the negative externalities derived from private vehicles' mobility are closely related at a municipal level (Pearson coefficient 0.84, $p = 0.00$). However, the modal distribution does not seem to be directly related to these factors, but is instead more conditioned by access to infrastructures, the location of the municipality, or the topography.

Sustainable modes of mobility in Mallorca are still in an embryonic state. The main dependence on the use of private vehicles is evident for any trip, whether it is for a long time, for a particular reason, or from a specific place. The failure to adopt a sustainable model in time gives rise to negative impacts derived from the use of private vehicles (congestion/pollution), resulting in a deterioration of Mallorca's image as a tourist destination.

The island's diffuse urbanization model, which is deployed radially from Palma towards coastal towns, contributes to the dependence on private vehicles. The transport development model has been characterized by infrastructure plans with enormous environmental and social costs. The new mobility planning developed by the Regional and Island Government's Sectoral Master Plan for Mobility proposes substantial changes towards sustainable modes. Its implementation will require considerable economic investment to deploy the railway network and to take various actions to promote sustainable modes. In any case, it is considered a priority to guarantee the coordination of the plan with other territorial, urban, infrastructure, and tourism plans and to consider mobility as an integral and important issue.

Finally, to ensure the viability of sustainability planning and the joint work of the different administrations, it will be necessary to promote a cultural change in the population towards the acceptance of and preference for sustainable modes. In this sense, initiatives to use shared vehicles and financial support instruments for sustainable modes may be considered alternatives in the coming years.

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