



Article Identification of Mobility Patterns in Rural Areas of Low Demographic Density through Stated Preference Surveys

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Abstract: Within the multiple urban-rural interactions that make up the territorial dynamics, this article addresses and identifies how mobility relations are produced between neighbouring municipalities that share services. The aim of this research is to carry out a diagnosis of the current mobility situation in an area of low population density in order to identify the needs and possible shortcomings in this area. The initial identification of weaknesses is essential in order to propose solutions for rural mobility. The methodology adopted is based on two distinct lines of work: (1) analysis of information in open data from public repositories using geographic information system tools (GIS), and (2) surveys of citizens living in the study area. The results allude to the fact that the most transcendental problem in the study area is the lack of a quality collective public transport service that meets minimum utility requirements for users, a fact that generates a transfer towards the use of private vehicles. No serious parking, noise, pollution or road safety problems are observed; however, similar dynamics to other rural areas with low demographic density are confirmed, such as the age of the mobile fleet and an aging population with accessibility problems. The presence of new modes of transport (electric bicycles, personal mobility vehicles, and even electric vehicles) is practically insignificant. Both teleworking and the new consumer habits associated with online shopping have not yet had a strong impact. Political decision making by public administrations is identified as a direct application of this research.

Keywords: open data; geographic information systems (GIS); new modes of transport; vehicle fleet; ageing population; COVID-19

1. Introduction

Since the middle of the 20th century, European urban planning has begun to shape an urban and territorial model that gives priority to the use of cars, which has had a significant impact on the dependence on private vehicles for everyday journeys [1,2]. Thus, one of the main challenges that started to develop for large and medium-sized cities is the evolution of mobility towards more sustainable models [3], based on establishing the compact city as the urban model, as its morphology allows for better efficiency and urban liveability. The urban morphology of European cities shows a series of characteristics that directly affect the movements of the inhabitants of these cities and their immediate environment, defining them as diffuse cities [4,5]. This morphology has led to the expansion of cities and decentralisation of services from the urban centres [6], increasing the distance travelled from areas of residence and industry to the point of location of new public utilities [7,8]. This growth in travel distances has led to an upward trend in the use of the private car as a regular means of transport [9]. This makes the spatial organisation of these main urban centres unsustainable, due to the emergence of problems related to traffic congestion on the road network, which ultimately have a negative impact on environmental and socio-economic issues [10].



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Copyright: © 2022 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https:// creativecommons.org/licenses/by/ 4.0/). These factors, whose origin resides in the European city model, have led to the active promotion of a sustainable urban mobility model since the beginning of the 21st century, with the aim of mitigating the effects of the use of private vehicles as the main means of transport, reducing their share of daily mobility and promoting soft means of transport that effectively reduce the environmental impact [11,12].

The key objective of this study is to investigate and develop more sustainable and efficient mobility in the Network of Sustainable Municipalities of Cáceres (RMSC). Initially, it analyses the problems associated with the over-use of private vehicles in rural areas, with the aim of promoting a more sustainable mobility that is in line with the economic development of these municipalities. In parallel, it aims to implement the use of sustainable mobility networks and to foment sustainable means of transport (pedestrian and bicycle), as well as to propose innovative measures to improve accessibility in urban environments and to optimise connections. It can be seen that the achievement of the above goal is linked to the sustainable development strategies and specifically to the Sustainable and Integrated Urban Development Strategy (EDUSI) [13] for the city of Cáceres and its 21 municipalities, as well as with the development of the SUMP for this area of action, which aims to meet the challenges identified by society through a process of citizen participation in mobility and transport.

State of the Art

Therefore, it is necessary to analyse mobility in more depth. It is becoming one of the fundamental areas of study within rural and urban areas and is considered an important aspect for the improvement of sustainability in the territory, because, among other reasons, it has as a priority objective the reduction of emissions caused by motorised means of transport [14,15]. In addition to limited mobility needs in compact urban centres, a change towards sustainable models of existing mobility flows is also necessary, as both rural and urban areas share territorial dynamics that generate daily pendular movements of population between them [16,17]. For this purpose, many cities have for years been developing measures to promote modal shifts from motor vehicles to sustainable modes of transport [18,19], with the objective of reducing the ecological, socio-demographic and economic impact on the territories that delimit them [20]. Therefore, it is of paramount importance to start implementing sustainable mobility strategies that are coordinated with supra-municipal authorities, so that sustainable mobility policies can reach the territory beyond the limits of the central municipalities [21]. One of the current challenges is to analyse daily mobility in the areas associated with larger population centres, so that by using data processing techniques it is possible to establish a mobility follow-up of the population in order to evaluate the viability, impact and efficiency of the measures to be implemented [22,23].

As a result of the COVID-19 pandemic, activity in urban and rural areas came to a complete standstill during the first months of the year 2020, from March to May. In this situation, the different restrictions to prevent citizens from becoming infected meant that no travel of any kind took place, except for that carried out for health reasons [24–26]. In this way, urban and inter-urban mobility was significantly affected, with journeys being significantly reduced. Public transport [27–29] suffered a greater impact, as it was initially associated with increased exposure to COVID-19 infection. This caused an increase in the use of individual modes of travel, in which it was estimated that exposure to COVID-19 infection was drastically reduced, leading to the predominant use of bicycles, electric bicycles, personal mobility vehicles (PMVs), as well as a preference for walking [30,31]. In order to limit commuting as much as possible, teleworking began to be introduced to avoid commuting to the workplace. In addition, learning and the use of new technologies led to an increase in e-learning and online shopping and with the aim of reducing the need to travel to work [32,33].

This set a precedent and changed the mentality of both public authorities and citizens, focusing attention on providing as many spaces as possible with the basic needs to be

able to carry out this type of activity. Thus, on the one hand, the implementation of new technologies in rural areas was prioritised, with the intention that citizens would be able to avoid travelling for work, leisure and shopping purposes. The aim was to bring new facilities to these areas that would allow them to develop socioeconomically and demographically [34].

Sustainable modes of transport (walking, cycling, Personal Mobility Vehicles (PMVs) and public transport) must become the basis for the development of alternative mobility in Spanish municipalities. With this premise, this type of mobility must be encouraged by promoting the use of bicycles and PMVs with the implementation of infrastructure that guarantees the safety of these means of transport [12,35,36]. Therefore, quality services must be established to motivate the population to use these modes of travel to free cities from motorised vehicles [37]. At the same time, the safety of bicycle users and PMVs are essential for raising awareness of the use of these transport modes [38,39]. Also of great importance is the correct spatial location of networks of rental points for these types of vehicles, as well as the implementation of specific parking areas in institutional buildings and tourist attractions (strategic locations that would facilitate the promotion of their use) [40]. Walking is a fundamental pillar of sustainable mobility, both in urban areas and in rural areas, which is why pedestrian accessibility on public roads should be one of the main objectives of local administrations. It is therefore appropriate to place special attention on facilitating access to pedestrian areas by citizens, avoiding any obstacle that could make walking difficult, focusing mainly on the group of people with reduced mobility [41].

With the aim of improved mobility in urban environments, many studies have been carried out with the goal of achieving a balanced system, with the sustainability of journeys cited as a priority. In addition, the development of Sustainable Urban Mobility Plans (SUMPs) has become a key tool that has promoted the implementation of new, more sustainable forms of travel in the urban space [42–44], with the idea of reducing the energy consumption and pollutant emissions caused by motorised vehicles, allowing a significant improvement in the quality of life of citizens as well as greater social cohesion and economic progress [45–47].

2. Study Area

This research focuses its attention on the analysis of mobility in RMSC, which was created to implement the EDUSI of the municipalities bordering the city of Cáceres (Figure 1).

Cáceres is a mid-sized city located in the centre of Extremadura. It is bordered by 21 municipalities that make up the RMSC and borders the province of Badajoz to the south. Thus, there is a clear dynamic of movement, with a daily flow of trips between the smaller municipalities to the city of Cáceres, thus giving rise to pendular movements from these surrounding municipalities towards the provincial capital, since this city is the socio-economic, administrative and commercial centre of this territory.

The daily movements of the population living in the RMSC of the study area (mobility between the municipalities that compose it and around the city of Cáceres), are facilitated by the structure generated by its important network of communication routes. In this sense, the study area has a favourable situation in terms of road transport, mainly due to the presence of three high-capacity roads: A-66, A-58 and A-5. The A-66 motorway runs from north to south and divides the study area in half, connecting to the north with Plascencia, some 80 km away, and to the south with the capital of the autonomous community (Mérida), some 75 km away. For its part, the A-58 motorway serves as a connection between the cities of Cáceres and Trujillo (separated by a distance of approximately 45 km). The A-58 in turn serves as the backbone to connect the municipalities located in the eastern part of the network with the city of Cáceres and the A-5 motorway. The A-5 connects, via the aforementioned A-58, with the central area of the peninsula and, in particular, with the city of Madrid (approximately 250 km). Similarly, it is necessary to mention the network of national and regional roads that link the most dynamic municipalities of the RMSC with the city of Cáceres (which is the centre of development of the neighbouring



municipalities). In addition to this, there is the road network of the Cáceres Provincial Council, which branches off to the connections with networks of higher capacity and allows interconnections between municipalities of smaller population size.

Figure 1. Location map of the study area.

In contrast, at present, the railway connection is limited to the service provided by the Madrid–Cáceres–Badajoz line, which connects the study area with Mérida and Badajoz to the south, and with Plascencia, Talavera de la Reina and Madrid to the northeast, highlighting the future incorporation of the Madrid–Extremadura high-speed line, which is currently completing the process of adapting the tracks for the circulation of high-speed trains. However, there is no effective railway connection between the municipalities in the study area and the city of Cáceres.

3. Materials and Methods

The research carried out in this article is based on the premise of two lines of work: (1) obtaining and analysing data in open format from public repositories, (2) carrying out surveys of citizens living in the study area. Figure 2 shows the methodological process of this study.

In the first step, valuable data were collected from different sources of information belonging to multilevel official bodies. In particular, detailed information was obtained on the situation of private vehicles in the municipalities that make up the study area, in order to determine the rate of vehicle use in the RMSC, the types and number of vehicles, the census of drivers and the type of fuel used by the vehicles analysed.



Figure 2. Methodology flowchart.

Secondly, the study was based on mobility surveys carried out with the participation of the inhabitants of the RMSC, addressing relevant aspects such as the changes in the mobility of the inhabitants of the study area following the COVID-19 pandemic and the new modes of mobility promoted as a result of this situation.

3.1. Information Sources and Data Collection

The procedure for collecting the information contained in the different official repositories (public data) relating to the RMSC was developed through the compilation of the documentation via the websites of the main official bodies, whether national, regional or provincial. The main sources of information consulted are listed below (Table 1):

- General Directorate of Traffic (DGT): data on the vehicle fleet linked to the RMSC were obtained from this body, as well as the demand for state-owned roads that run through the area under study.
- National Centre for Geographic Information (CNIG) and the Territorial Information System of Extremadura (SITEX): these were the public tools that made it possible to obtain geographic information on the municipalities in the study area, both in terms of transport networks and municipal and provincial boundaries.
- National Statistics Institute (INE) and the Extremadura Statistics Institute (IEEX): both
 official sources were used to provide information on socio-demographic data, making
 it possible to obtain data on the population of each municipality in the RMSC, as well
 as different socio-demographic and economic indicators.

Data Source	References	
General Directorate of Traffic (DGT)	[48]	
National Centre for Geographic Information	[49]	
Territorial Information System of Extremadura (SITEX)	[50]	
National Statistics Institute (INE)	[51]	
Extremadura Statistics Institute (IEEX)	[52]	

 Table 1. Data sources for the study.

After all the relevant information was selected, it was analysed to calculate the following parameters: the percentage of registered drivers out of the total population, the motorisation rate of the municipalities that make up the study area (both in terms of the total number of vehicles that make up the vehicle fleet and in the case of passenger cars), the analysis of road accidents with victims and the average age of vehicles in the vehicle fleet per municipality. Table 2 shows the formulas used for their calculation.

Table 2. Calculation formulas for the parameters studied.

Parameters	Formula	
Variation rate of census of drivers	(2014 drivers' rate—2020 drivers' rate)/2014 drivers' rate	
Variation in the rate of motorisation	(2014 motorisation rate (‰)—2020 motorisation rate (‰))/2014 motorisation rate (‰)	
Variation in the rate of	(2014 car motorization rate—2020 car motorization	
motorization of cars	rate)/2014 car motorization rate	
Road accidents	(Total road accidents per municipality (2014–2020))/Total Road accidents in RMSC) * 100	
Average age of vehicle feet	Average vehicle fleet per municipality (2014–2020)	

Based on the parameters obtained through the different calculations, geographic information system tools (specifically the free and open source software QGIS 3.16.16) were used for the processing, analysis, visualisation and interpretation of the data. This resource allows the materialisation of information on the territory by means of the elaboration of thematic maps as a geographic information system and is an indispensable tool for managing the dynamics of georeferenced data and information for any form of territorial planning [53]. Thus, through the different analyses carried out, the aim is to show the situation of the municipalities that make up the area under study. Therefore, data from different public bodies were compiled, obtaining information at the municipal level for the period 2014–2020, with the aim of observing the existing variation of different aspects related to the mobility patterns of these municipalities.

3.2. Mobility Surveys

The study was completed with the results obtained from the surveys carried out on the changes in mobility caused by COVID-19 and the new mobility habits that are being developed. In this way, the aim is to analyse mobility from two opposing points of view that allow us to study the main problems of the study area in more depth, as well as to determine the opinions of citizens with respect to the modal change of mobility in order to make more sustainable journeys.

For the purpose of first-hand collection of citizens' opinions and perceptions on the different issues addressed by this study, it was decided to carry out surveys in each of the municipalities in the study area in order to deduce the specific mobility patterns of this rural area of low demographic density. Two different types of survey were chosen: revealed preference (RP) and stated preference (DP) methods. First, through the mobility surveys [54], the aim is to obtain information about the real behaviour of individuals and, in this way, to be able to locate the aspects that generate problems regarding the existing transport options in the municipalities of the study area. Second, through declared mobility surveys [55], the population is presented with a series of proposals with the aim of gathering their opinion on these transport alternatives.

The period in which the surveys was carried out was between May and July 2021, and 6 months was required to process the information obtained. The data collected through the citizen participation surveys represent valuable information for public authorities, as they are an essential starting point for those responsible for territorial planning. The quantitative methodology based on surveys is supported by its widespread use in mobility studies [56–58], and its use also allows for the chronological monitoring of the variables studied. Focusing on the content of the surveys, in order to determine the changes in mobility generated by the COVID-19 pandemic, a thematic block was established, in which the aim was to examine in depth how the disease had affected daily commuting, the use of public transport and the implementation of teleworking among those surveyed, as well as consumer habits.

On the other hand, there was another section that referred to new mobility. In the questions belonging to this section, the focus was placed on the availability and use of bicycles or PMVs among the respondents. In addition, questions were asked about the use of public transport and the existing problems in this type of mobility as well as pedestrian mobility. A number of new mobility proposals related to the use of bicycles and electric vehicles were submitted to the respondents for evaluation. Finally, a series of questions was asked in order to address the parking situation in the city centre of Cáceres, the usual destination of the daily trips originating in the RMSC.

Sample Size

A total of 294 valid surveys were carried out for the 36,909 population of the study area, which means an approximate margin of error of $\pm 5\%$. Table 3 shows the types of people surveyed according to gender, age, employment status, length of journey made and use of public transport.

Category	Subcategory	N	%
Gender	Male	105	35.71%
	Female	187	63.61%
	Prefer not to say	2	0.68%
Age	20–29	26	8.87%
	30–39	43	14.68%
	40-49	75	25.60%
	50–59	85	29.01%
	60–69	37	12.63%
	70–79	24	8.19%
	80–89	3	1.02%
Employment status	In retirement or early retirement	52	17.75%
	Unemployed	29	9.90%
	Studying	8	2.73%
	Other situation or inactivity	13	4.44%
	Homemaker	18	6.14%
	Working	174	59.04%
Use of public transport	Daily	5	1.76%
	A few times a month	10	3.52%
	Never	150	51.06%
	Occasionally	121	41.20%
	Several times a week	7	2.46%

Table 3. Survey sample by category.

Therefore, the following formula was used to calculate the error margin of the surveys carried out and obtain a result that validated them:

$$n = \frac{N \cdot z 2\alpha 2 \cdot p \cdot (1-p)}{e 2 \cdot (N-1) + z 2\alpha 2 \cdot p \cdot (1-p)}$$

The values used for the calculation of the error margin are as follows: the population size is N = 36,909 for the rural municipalities of the RMSC; the sample size is n = 294, with a distribution of p = 0.5. Because of this, the confidence level is 95% (1- α), so the value $z\alpha/2 = 1.96$. As a result of this calculation, the margin of error is \pm 5%.

4. Results

These results are presented in two complementary ways: on the one hand, they are spatially represented by means of maps produced with geographic information system tools and, on the other hand, the numerical data are presented with visualisation in graphical format for a better understanding. Five areas of analysis are considered: (1) mobility in private vehicles, (2) pedestrian mobility, (3) cycling mobility, (4) public transport mobility and (5) mobility as a service and new forms of mobility.

4.1. Mobility in Private Vehicles

The car is considered to be the main problem that exists within the RMSC with regard to the development of more efficient and sustainable mobility. This issue is presented and discussed in detail below.

4.1.1. Census of Drivers

Data provided by the DGT show that in 2020 the RMSC had a total of 25,348 drivers, which represents 59.14% of the total population of the study area. These data reflect the fact that 40.85% of the population of the RMSC is in a situation of dependence on other members of their family unit or close environment for their mobility in their private vehicle or requires the use of efficient means of public transport for longer distance journeys (outside their town of residence). The demographic data obtained in the survey regarding the gender of the inhabitants of the RMSC shows that 62.72% of drivers are male and 37.28% are female, thus demonstrating a marked inequality and a greater dependence of women on transport.

Figure 3 shows the variation in the driver census obtained between 2014 and 2020, showing an increase in most of the municipalities in the study area, except for the case of Plasenzuela, which shows a slight reduction in the driving population.

The results in Figure 3 show that the municipalities with the greatest variation were: Botija, Casas de Don Antonio, Herreruela and Santiago del Campo, which coincides with the municipalities with the lowest population in the study area. This fact translates into a cause–effect relationship that is reflected in the decline of public services in these municipalities, making it necessary to travel by private vehicle to larger towns and generating a considerable increase in the population with driving licences. Just as the municipalities with the smallest populations saw the greatest increase in the number of registered drivers, those municipalities with the largest populations within the study area (Arroyo de la Luz, Brozas and Casar de Cáceres) saw a slight increase in their driving population. In the opposite case, the only municipality showing negative values was Plasenzuela, a circumstance interrelated with the loss of population suffered in recent years in the municipalities of the RMSC, mainly by the age groups with the possibility of having a driving licence.

4.1.2. Vehicle Fleet

The excessive use of motor vehicles is one of the main issues that this study aims to address. Thus, the information obtained on the vehicle fleet in the study area is used to analyse its evolution in recent years and its impact on the population of the study area. Thus, information was obtained on the mobility in private vehicles of those cars, vans, motorbikes, mopeds or privately owned industrial vehicles used for the daily travel of residents. Based on this information, the motorisation index of each municipality was calculated in absolute values, an aspect that allows the degree of dependence on private vehicles to be identified as well as the variation in the fleet of vehicles in the RMSC between 2014 and 2020.



9 of 25



Figure 3. RMSC driver census (2014-2020).

With reference to an initial analysis in absolute values, in 2020 the vehicle fleet in the study area was made up of a total of 35,281 vehicles in accordance with the data obtained from the DGT, of which 65.97% were passenger cars. Based on the population of these municipalities and the number of existing vehicles, the average motorisation rate of the localities in the study area was 914.46‰, (which is a fairly high rate). If the motorisation rate is limited exclusively to cars (the main means of private transport), the RMSC has an average rate of 596.72‰ in 2020.

Figure 4 shows that in recent years the number of vehicles in the RMSC has gradually increased, with an increase in the number of vehicles in the municipalities that make up the RMSC, with the exception of Plasenzuela. The greatest variations in the motorisation rate are found in the municipalities of Botija (0.29), Herreruela (0.28), Casas de Don Antonio (0.28) and Santiago del Campo (0.27). These municipalities show an index above 1000‰ in the overall motorisation rate.

The map below (Figure 5) shows the motorisation rate of passenger cars in the municipalities of the study area. There is an increase in the number of passenger cars in the RMSC in the period from 2014 to 2020, but it is less pronounced than the total number of vehicles. As in the general motorisation rate, the municipalities with the greatest variations were: Santiago del Campo (0.35), Botija (0.33), Casas de Don Antonio (0.27) and Herreruela (0.24). In comparison with the above data, the municipality with the greatest variation was Santiago del Campo, which indicates that there was a greater increase in the number of private vehicles in this municipality.



Figure 4. General motorisation of the RMSC (2014–2020).



Figure 5. Motorisation of passenger cars in the RMSC (2014–2020).

4.1.3. Road Accidents

An analysis of road safety in the RMSC is considered necessary in order to identify in more detail the conditions of mobility in private vehicles. In order to determine the evolution of the accident rate over the last few years, essential information was collected from the DGT through road accident data generated from 2014 to 2020.

In Figure 6, the percentage distribution of the total number of accidents that occurred in the municipalities of the study area in the time period under consideration is shown. In addition, a graph is provided to compare the number of accidents recorded in the city of Cáceres with the total number of municipalities in the RMSC.



Figure 6. Road accidents in the RMSC (2014-2020).

The evolution of the accident rate in these municipalities remained practically linear, with slight fluctuations that were not very accentuated. In the RMSC, 2017 was the year with the highest number of accidents, with a total of 17. Compared with the data available for the city of Cáceres, the RMSC had a much lower number of accidents than the provincial capital, with figures above 100 accidents in most of the years under study, except for 2016, with 49 accidents.

In terms of the percentage of accidents caused during the entire study period, the municipality with the highest value is Trujillo, accounting for more than 22% of the accidents in the RMSC. The case of Trujillo stands out for being the municipality with the largest population in the study area, which leads to a greater number of vehicles and greater conflict situations with pedestrians and between vehicles, as well as being a municipality where several roads converge. The municipalities of Arroyo de la Luz and Casar de Cáceres are also noteworthy, each accounting for more than 14% of total accidents. It is considered necessary to detail the existence of a group of municipalities in which no accidents were recorded during the analysis period: Botija, Casas de Don Antonio, Herreruela, Montánchez, Santa Marta de Magasca, Santiago del Campo, Sierra de Fuentes and Plasenzuela.

The Spanish vehicle fleet is one of the oldest in the European Union, which means a greater risk on the roads and also a notable increase in pollution caused by cars. In addition, the age of the vehicle increases the risk of death or serious injury in the event of an accident, as new vehicles incorporate safety systems that older vehicles do not have. It can be seen that the most depopulated provinces and those linked to the rural world (which have an older population) are those with the oldest cars.

The analysis of the vehicle fleet's age makes it possible to interrelate road accident statistics with mobility, while at the same time demonstrating how the objectives set by European, national and regional institutions to reduce emissions are becoming more complicated.

Figure 7 shows how the fleet of vehicles in the RMSC is rapidly ageing, with an average age of close to 13 years in 2020. It can also be seen that the vehicle fleet in the study area has shown a notable increase since 2014.



Figure 7. Vehicle fleet age of the RMSC (2014–2020).

The municipalities with the oldest average age of their vehicle fleet are: Herreruela (14 years), Garrovillas de Alconétar (13.9 years), Aliseda (13.7 years) and Santa Marta de Magasca (13.5 years). It can be seen that these figures are characteristic of depopulated and ageing rural areas in several Spanish provinces. According to data collected by the DGT [47], in Spain, provinces with an older population and associated with the rural world have an older vehicle fleet, since there is no need to change vehicles in the same way as in more dynamic regions, and generally, it is common to exhaust the useful life of the car.

4.1.5. Problems Associated with Private Vehicles

To identify the problems derived from the excessive use of private vehicles in the RMSC, the surveyed population was asked to evaluate the most significant aspects of this

means of transport. Therefore, Figure 8 shows the assessment of the problems associated with the car in terms of on-street parking, traffic, road safety, noise and pollution.



Figure 8. Problems associated with private vehicles in RMSC.

In terms of on-street parking in the municipalities within the study area, only 29% of respondents reported that they perceived this situation as deficient, compared to 71% who did not perceive any problems related to parking in their municipalities.

Other possible problems that may derive from the use of private vehicles are those related to traffic and especially those related to road safety, or the perception of road safety by the inhabitants of the municipalities. In relation to the above, 70% of those surveyed did not perceive any traffic problems or problems in terms of road safety in their municipalities. In those municipalities that have a certain amount of road crossings: Arroyo de la Luz, Malpartida de Cáceres, Trujillo, Torremocha, Torreorgaz or Torrequemada, it was not observed that these percentages varied due to this particularity.

Finally, opinions about noise and pollution from vehicle traffic were determined, which showed that 73% of the people surveyed did not believe that there were any problems of this type in their municipality. Only 28% of people found this situation to be deficient.

4.1.6. Parking: Problems and Solutions

The high percentage of journeys made in private vehicles in the RMSC makes it very important to analyse the parking of these vehicles, both at the origin and at the destination of their journeys. This analysis allows for the detection of the shortcomings or problems related to this aspect, thus making it possible to propose alternatives and solutions in the cases that require them. Figure 9 below shows the parking situation in the city of Cáceres.





With regard to parking at the place of destination, there is clear preference among those surveyed for parking on the street, especially where there is no blue zone pricing (63% of those surveyed). The second most used option is parking, with 26%. As discussed

above, Cáceres is the main point of attraction for journeys from the rest of the municipalities that make up the RMSC. Since private vehicles are the main means of transport chosen to travel to the capital of Cáceres, one of the main drawbacks in accessing the city is finding a parking space in the city. When asked about parking facilities within the city centre of Cáceres, 87% of those surveyed considered them to be unsatisfactory or very unsatisfactory, making it clear that there is a parking problem in the city.

Related to the above, Figure 10 shows the respondents' opinions on the conditioning factors for the use of park-and-ride facilities located at the entrances to the city of Cáceres and connected by public transport to the city centre and various points in the city, also known as park-and-ride facilities. A total of 62% of respondents stated that they would be willing to use this type of parking. When it comes to using this type of car park, the factors that would influence their choice of car park would be the frequency of the connecting bus service (30%), the price of parking (27%) and the variety of destinations (19%).





When analysing the on-street parking situation in the different municipalities that make up the RMSC, no significant difficulties were found. In certain municipalities, the characteristics of their urban centres and the size of their streets can make parking difficult, causing problems for traffic circulation, as is the case in Montánchez and Brozas. These situations mainly occur in the summer, when there is a greater influx of vehicles. Given the possibility of creating new parking areas in these municipalities, the lack of available space makes them unviable alternatives.

4.2. Pedestrian Mobility

In order to gain a better knowledge of the real situation of pedestrian mobility in the municipalities of the RMSC and to understand what the main problems are, the method of analysis used was to carry out surveys of revealed preferences.

It can be seen that pedestrian mobility within the municipalities is varied, with some municipalities having more complex mobility and accessibility due to their orography or the characteristics and dimensions of their roads and pavement.

4.2.1. Pedestrian Space and School Pathway Assessment

Through the surveys carried out among the population of the RMSC, the purpose of the surveys was to find out how citizens rate the main aspects of pedestrian mobility.

An estimate of the availability of pedestrian space in municipalities is shown in Figure 11. In response to the question asked in the survey, 73% of the users answered that the available space was sufficient or more than sufficient, so that this aspect could not be considered a serious problem in the surveyed municipalities.



Figure 11. Pedestrian space assessment.

Due to the existence of a higher percentage of journeys made on foot, for study purposes, it is important to assess the existence of school routes in the rural municipalities in the study area. In this sense, 41% of those surveyed rated the situation as bad (27%) or very bad (15%), possibly due to the lack of signposting on this type of route.

4.2.2. Problems Detected

Pedestrian movement is regulated to a large extent by the capacity of the pedestrian space and the infrastructure available to carry out such movements. As can be seen in Figure 12 and in relation to the above, survey respondents were asked to identify and rate the main difficulties they might encounter in their daily pedestrian mobility.



Figure 12. Pedestrian problems in the RMSC.

The results of the surveys showed that the main problem detected would be related to the characteristics of the pavement, with 23% of the respondents considering the pavement to be narrow. In contrast, 14% of respondents indicated a deficit in accessibility due to obstructions or poor pavement conditions. When respondents were asked to rate the overall condition of the pavement, 41% of respondents said that their urban condition was either poor (29%) or very poor (12%).

4.3. Cyclist Mobility

In the RMSC, there is much room for improvement in cycling infrastructure. In urban areas, in the great majority of municipalities there is no infrastructure, and cyclists have to share the road with other vehicles. The graph (Figure 13) shows the analyses of the frequency of cycling and the motivation for its use in the RMSC. It can be clearly seen that the rates are negative, as there is hardly any use of this means of transport. A total of 54% of users do not use bicycles; those who use them occasionally account for 25% of those surveyed, and only 6% of those surveyed use this means of transport on a daily basis.



Figure 13. Cycling mobility situation in the RMSC. (**a**) Cycling frequency; (**b**) Reasons for cycling; (**c**) Cycling facilities; (**d**) Cycling difficulties.

The citizens surveyed who use bicycles occasionally, several times a month or daily, the frequent users of bicycles, use this means of transport for sport and not for work or educational purposes, accounting for about 70% of the population surveyed.

In the figure above, we can see how citizens rate the facilities for cycling in their municipalities. In general terms, the assessment of cycling is relatively positive, with 59% of those surveyed considering it to be excellent (6%), good (20%) or acceptable (33%). However, a high percentage of those surveyed considered that there were no facilities available for cycling as a means of transport, with 41% of those surveyed describing them as deficient or very deficient in their municipalities. As shown in the graph above, the main problem faced by the RMSC's inhabitants when using bicycles was the fear of sharing public space with motor vehicle traffic, accounting for 35% of the responses. Other problems reported by respondents to the survey include the excessive physical effort required (29%) and the longer journey time (13%). Other problematic factors to be taken into account are the unfavourable climate (13%) and the unavailability of adequate and safe parking areas at the destination (10%).

Surveys were carried out to obtain citizens' evaluations of the situation of cycling mobility infrastructure, but also to determine how well citizens accept the improvement and incorporation in their municipalities of infrastructure that promotes the use of this means of transport. Figure 14 shows the level of acceptance of two proposals that could improve cycling mobility in these municipalities: on the one hand, the creation of bicycle rental stations, and on the other, the construction of urban and inter-urban cycle lanes.



Cycle lane creation Bicycle rental points



The evaluation of the survey proposals was very positive, with 62% of respondents agreeing or strongly agreeing with the installation of bicycle rental points and 73% agreeing with the creation of bicycle lanes. On the other hand, 8% of respondents disagreed or strongly disagreed with the creation of bicycle rental points and 10% on the issue of bicycle lanes; however, this figure is not very representative.

4.4. Public Transport Mobility

The bus is the main means of public transport service in the RMSC, which is why it is the element of mobility that has shown the greatest number of weaknesses and problems in the surveys carried out. With regard to the use of this means of transport by users, Cáceres is the main and almost exclusive destination in the majority of cases, considering the origin of the trip to be journeys from each municipality in the network.

The surveys of the residents of each municipality showed that the main problem (as shown in Figure 15) was related to the timetables of the service and the lack of accommodation to the needs of the users, with 54% of the results. In second place, but with a much lower percentage (14%), respondents reported as the main problem that the final destinations of their journeys could not be reached by using this means of transport. Along the same lines is the poor location of the public transport stops of the lines that operate passenger transport from the municipalities of the RMSC to the city of Cáceres. In the capital, the only official stop for inter-municipal bus lines is the Cáceres Bus Station. Although the problem of location was only considered the main problem by 4% of those surveyed, this is due to the fact that, unofficially, some of these bus lines make other (unauthorised) stops within the urban area of the city of Cáceres, providing their users with better accessibility to their final destinations.



Figure 15. Disadvantages of public transport in the RMSC.

To understand better the use of the bus service, Figure 16 shows the analysis of the frequency of use of the bus service by its users. It can be seen that only 8% of users use it regularly. It is also evident that more than 50% of those surveyed never use public transport. On the other hand, it should be noted that more than 40% of respondents use public transport occasionally.





In this section we analyse the impact of the COVID-19 pandemic on the use of this means of public transport (Figure 17). In order to understand how the pandemic has caused differences in the percentage of users of this mode of transport and whether these differences could be affected by the age range of the users, the survey asked users about this issue.

The results of the survey show that around 60% of those surveyed do not currently use the bus, and the age range that makes the least use of public transport is between 40 and 60 years of age (66%). The reasons for the poor use of public transport can vary greatly between the different age groups, but it is mainly due to the limited timetable of this means of transport and its connections with the city of Cáceres, which makes it difficult for users to make the journeys necessary to cover their needs. Thus, people over 60 years of age are the age group in which the use of the bus has been most reduced due to the pandemic (32%), mainly due to the consequences of the disease and the measures related to it.



 \equiv Under 40 \equiv 40 to 60 \boxtimes Over 60

Figure 17. Public transport use in the RMSC after COVID-19.

4.5. Mobility as a Service (MAAS) and New Forms of Mobility

The rise of new working methodologies (teleworking) as well as the explosion of online shopping has had a strong impact on the way commuting is done (Figure 18). In the wake of the COVID-19 pandemic, teleworking has experienced an exponential increase. Among its main benefits is that it has enabled workers to reside in municipalities other than where their workplace is located. This phenomenon could help to stem depopulation in areas where the demographic curve has seriously declined in recent years.



Figure 18. Mobility changes in the RMSC: (a) commuting after COVID-19; (b) teleworking in the RMSC.

Teleworking as a new working dynamic has not been significantly implemented in the municipalities of the RMSC as a whole. The survey provides estimated values of 10% of workers who use this modality with a certain degree of regularity, but it cannot be excluded that this percentage may continue to increase in the future.

At the same time, another activity strongly linked to the internet and mobility is consumption habits and, in particular, the way in which the inhabitants of the RMSC make their household purchases. The situation caused by COVID-19, with the consequent reduction in mobility over a given period of time, has brought about a series of changes in consumer habits (Figure 19).



Figure 19. Consumer habits in the RMSC after COVID-19.

However, there is a clear difference in these habits due to the technological gap according to age, with the population over 60 years of age preferring to continue shopping in physical shops (71%), while the rest of the population, especially those under 40 years of age, tend to opt for online shopping or a combination of both types of shopping.

5. Discussion

The research was carried out to analyse segregated mobility in the RMSC, with the objective of determining the real situation in this area and the problems associated with each type of mobility analysed: mobility by private vehicle, pedestrian, cyclist, public transport and new forms of mobility. The results obtained made it possible to confirm the situation of the study area, in which there is a significant predominance of private vehicles caused by inadequate timetable frequency of public transport and the need to travel to the city of Cáceres for different reasons. At the same time, we identified the different associated problems that lead the population of the study area not to make their journeys by foot or bicycle or by means of new types of mobility, such as personal mobility vehicles (PMVs).

In contrast to what one might think, this preponderance of private vehicle use does not translate into the perception of a clear associated problem, as no problems with parking, noise, pollution or road safety were reported in the municipalities of the RMSC. In this area, the main problem is the difficulty of parking in the city of Cáceres for the population of the RMSC, as they have to make journeys due to the lack of services in their municipalities of origin. It was associated as one of the reasons that discourages citizens from cycling in urban environments.

According to the social situation of the municipalities of the RMSC, there is almost no bus connection with other neighbouring municipalities, which is one of the reasons for the lack of inter-municipal mobility [59,60].

The transport sector suffered significant losses due to the COVID-19 pandemic, as the mobility of people was drastically reduced for a significant period, which subsequently led to the implementation of social distancing measures and thus reduced capacity for public transport, causing economic and social losses [61]. This caused a considerable reduction in the number of journeys made by this means of transport [26,62], which this study has shown through the surveys carried out. Thus, in the case of the RMSC, a large part of the population reduced its use or does not use public passenger transport by bus at all.

In many cases, public transport journeys are motivated by an essential reason (such as a doctor's appointment or administrative procedures), which means that users are obliged to travel by public transport. In such a scenario, they usually decide to opt for another alternative, generally travelling in a private vehicle, either through a relative or neighbour. Thus, as indicated by Refs. [61,63], there is more difficulty in access to services for the over-60s than for other age groups, and they are highly dependent on private vehicles.

The presence of new modes of transport (electric bicycles, personal mobility vehicles and even electric vehicles) is practically insignificant in all the populations in the area, contrary to what has been shown in other studies [30,64]. In this study area, COVID-19 has not led to an increase in the use of the conventional bicycle as a means of transport for commuting to work or school, and even the traditional bicycle is not perceived as a useful means of transport but rather as an element whose use is associated with leisure or sport. With regard to scooters and electric bicycles, as with the bicycle, in all the study populations their use is seen as more related to recreational, leisure or sporting activities than as a real means of transport. This, as indicated by different authors [65,66], permits the application of important changes associated with citizen mobility, with the aim of implementing more sustainable models that reduce the use of polluting vehicles.

The authors consider that the inclusion of e-bikes and e-scooters in daily mobility could supplement public transport trips in an ideal way, as shown in Refs. [67,68]. However, it is necessary to take into account the population pyramid and the characteristics of the study area, which is eminently rural and with elderly citizens who are reluctant to change and have a clear tendency to use private vehicles or public transport. Notwithstanding the foregoing, the implementation of recharging points for electric vehicles would allow other users to join these more sustainable forms of mobility and make them compatible (from the point of view of intermodality) with other modes of collective transport.

Additionally, during the COVID-19 pandemic, it was noted that no new infrastructure relevant to the improvement of mobility was built in the study area, with the exception of the Ronda Este (EX-C2) in the municipality of Cáceres. However, there are significant public initiatives, such as the call for proposals for the SUMP of the RMSC, the Extremadura Sustainable Mobility Plan (currently being drafted) and the workshops on modal shift organised by the Cáceres Provincial Council.

It is appreciated in this article that the scope of this type of research depends, to a great extent, on the quality of the starting data. The ability to access quality data sources, as well as to carry out extensive field work (based on stated preference surveys), can be the key factor in order to identify mobility patterns that allow good management in terms of land use planning. As a future line of work, it is planned to delve into this type of research, including accessibility calculations carried out with geographic information system tools (by means of network analysis), which will be added to conducting citizen surveys as well as obtaining data in institutional repositories.

6. Conclusions

In this study, a diagnosis of the current mobility situation in the RMSC was carried out by analysing data from public repositories and by carrying out surveys of the public.

The results obtained do not reflect serious problems of parking (a large proportion of users have a garage), noise, pollution or road safety in the municipalities, with the last issue sometimes being one of the reasons that dissuades potential users from cycling.

The excessive use of private vehicles can be considered the cause, or even the result, of what appears to be the most serious problem for the population of the RMSC as a whole, namely the unavailability of a quality public transport service that meets the minimum requirements of user convenience. Despite the infrequency of the service, users do not perceive it as the main problem of the service, but rather point to other circumstances: for example, 54% of the users report that the timetable does not suit them, especially when they return to Cáceres to carry out their business. In most cases, the problems associated with public transport are related to the incapacity to use the bus as a means of transport for work-related reasons. There were also complaints from those surveyed that users of public transport had to stay much longer than necessary in Cáceres for health reasons or to complete formalities, due to the frequency of the bus lines.

The results collected, excluding school transport users, show that the main users of public transport are older people who, in almost all cases, live alone and do not have their own vehicle, so that the above problem is perceived as more serious in areas where the percentage of older people is higher. This age group is also the most reluctant to use the bus as a result of the COVID-19 pandemic.

Walking should play an important role in the mobility of the municipalities in the study area, as it has been observed in the study area that a large number of journeys to schools, even when they are located within the same town, are made by private vehicle, which occasionally causes certain traffic problems. Therefore, a series of questions were asked to enable citizens to assess the most recent municipal actions, which in general are committed to a single platform, eliminating raised pavement where it exists, as in most cases the pavement is old and does not comply with the minimum widths or does not have sidewalks. It was observed that there are no purely pedestrian areas in any of the municipalities, with cars and pedestrians coexisting in all of the towns. Similarly, it was observed that the convergence of cars and pedestrians does not generate serious road safety problems, at least from the point of view of the surveyed population.

The presence of new modes of transport (electric bicycles, personal mobility vehicles, and even electric vehicles) is practically insignificant in all the towns in the area, being seen as something more related to leisure or sport than as a real means of transport, a great opportunity to promote sustainable urban mobility, as well as contributing to a positive environmental impact.

As for the new consumer and mobility habits resulting from COVID-19, no noticeable impact was observed among the surveyed population. Teleworking is a great opportunity to revitalise the rural environments of the study area, avoiding the use of private motorised vehicles and prioritising the use of more sustainable means of transport. Another of the most significant changes in citizens' habits as a result of COVID-19 is the increase in online shopping; although this habit has shown an exponential increase in recent years, the situation caused by the pandemic has led to a normalisation of this consumer habit.

This research confirms certain dynamics similar to other rural areas of low demographic density in Spain, such as the age of the vehicle fleet. We can also relate the problems associated with public transport to the socio-demographic characteristics of the study area, since the continuous ageing of the population, as well as the progressive loss of inhabitants in the municipalities that make up the area, has led to a reduction in the use of buses as a means of transport, and this has been combined with an inefficient timetable frequency. Another of the results obtained related to the aspects of rural areas are that the changes associated with the new mobility, both teleworking and the new consumer habits associated with online shopping, have not yet had a strong impact on the study area, being more developed by the new generations that reside in these areas.

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