Towards a MaaS for all. A Methodology to Identify the Determinants of Autonomy to Enhance the Mobility Capital of Vulnerable Social Groups in Sardinia (Italy)

Tanja Congiu[1], Sara Faedda[1(✉)], and Chiara Garau[2]

[1] Department of Architecture Design and Urban Planning, University of Sassari, Via Garibaldi 35, 07041 Alghero, Italy
sarafaedda2@gmail.com

[2] Department of Civil, Environmental Engineering and Architecture, University of Cagliari, Via Marengo, 2, 09123 Cagliari, Italy

Abstract. Mobility as a Service can be a key solution for sustainable and inclusive transport systems. By integrating different transport modes into a unique digital platform that suggests personalised travel solutions, it helps reduce reliance on the private car and provides both efficient and environmentally friendly mobility solutions while also ensuring equal access to mobility. This research explores the applicability of Mobility as a Service (MaaS) for all, looking at the determinants of its use by vulnerable groups of citizens. By providing an assistive technology that supports people in their door-to-door journeys, MaaS represents a useful tool for all users and especially for people with travel limitations (non-drivers, elderly, people with physical and cognitive impairments, etc.) who are at higher risk of exclusion from community life. The widespread use of navigation and journey planning apps, even among people with special needs, and the emergence of the MaaS concept, make these tools a real opportunity to increase the mobility capital and achieve social sustainability goals together with environmental and economical ones. However, barriers of diverse nature exist and limit the usability of new mobility solutions. To explore this issue, we propose an approach centred on people and their capabilities, starting with a survey on travel autonomy of vulnerable groups in the context of Sardinia. Individual and environmental factors that influence the ability to travel independently in the city and to use assistive technologies for mobility will be investigated, with the aim of capturing some enabling requirements to be included in the design of MaaS for all.

Keywords: MaaS · Vulnerable Social Groups, Survey · Social Accessibility · Sardinia

1 Introduction

Mobility as a Service (MaaS) can effectively be a pivotal solution for sustainable and inclusive mobility. Integrating different modes of transport into a unique digital platform that suggests personalised travel solutions aims to reduce reliance on the private

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car while delivering both efficient and environmentally friendly mobility solutions and ensuring equal access to mobility for all users. This research explores the applicability of MaaS for all, looking at the determinants of its use by vulnerable groups of citizens. By providing an assistive technology that supports people in their door-to-door journeys, MaaS represents a useful tool for all users, especially for people with travel limitations (non-drivers, elderly, people with physical and cognitive impairments, etc.). Such a paradigm, if properly implemented, could reduce the inherent inequities of the current transport system, where non-drivers are underserved. This is particularly important in regions characterised by low-density settlements, such as many parts of the region of Sardinia, where large parts of the population are ageing and the current transport system is weak and limited to minimum services and needs to be overhauled to take advantage of new mobility models [1].

The widespread use of navigation and journey planning apps, even among people with special needs, and the emergence of the MaaS concept make these tools a real opportunity to increase the mobility capital of people and to achieve social sustainability goals together with environmental and economic ones. However, barriers of diverse nature exist and limit the usability of new technological mobility tools.

The main goal of this paper is to examine the applicability of a MaaS for all, focusing on the factors influencing its use by disadvantaged people. The amplified effect that MaaS could have in providing more equitable access to urban opportunities and enhancing personal autonomy, particularly for those with mobility limitations, is the primary concern of this work. Indeed, there are large groups of citizens who are afraid or hesitant to travel for diverse reasons: physical and cognitive impairments, uncertainty about travel, not having a driving licence or not owning a car. For these groups of citizens, the risk of exclusion from community life is higher [2] and the MaaS platforms can help to increase their autonomy. In this sense, it has a very strong potential for inclusivity. The development of a MaaS for all is explored, taking the region of Sardinia as a case study. The article is organised into six sections. Sections 1 and 2 offer a theoretical introduction of the topic, Sect. 3 introduces the methodology used and describes a multi-layer analysis performed. The case study is then presented in Sect. 4 where some indicators relating to the socio-demographic trends of Sardinia and the mobility behaviour of people with disabilities are exposed. This data is then compared with the current transport offer to measure the availability of mobility options and their relative accessibility for this specific group of users. Section 5 defines the structure of a survey to be proposed to vulnerable people aimed at identifying limitations and enabling factors to travel independently. In the final section, some insights for achieving a MaaS for all are shown.

2 Accessibility and the Right to Mobility

Mobility is fundamental to everyone's freedom to access and participate in community life. It is a fundamental human right that underpins education, employment, healthcare and social interaction. As such, it is a prerequisite for social inclusion, which must be available, affordable, accessible and safe for all [3]. Everyone has the right to be mobile in space [4] in order to reach the opportunities that he or she has reason to value, according

to his or her needs, habits and behaviours, attitudes and interests [5, 6]. Mobility is shaped by personal, social and spatial features.

With respect to the spatial dimension, transport accessibility, intended as the availability of an efficient transport system that allows easy access to at least essential services [7] is key for the implementation of equity and cohesion policies.

In order to ensure a truly inclusive transport system and adopt solutions that ensure equal access to resources and services, it is essential to understand the needs of vulnerable social groups (VGSs) [8]. Indeed, the most vulnerable members of society are often those most affected by a lack of accessible transport services and connections (including local, diffuse and inter-suburban trips) to the nearest essential services [9]. Among several definitions of vulnerable populations, the one proposed by the European Commission [10] is quite comprehensive. It delineates the categories of individuals who experience conditions of vulnerability as a result of structural or individual characteristics. It considers "Vulnerable social groups" as individuals who are at a risk of poverty or social exclusion due to physical and cognitive impairments, age, economic status, as well as ethnic origin, homelessness or substance abuse [11]. Thus, vulnerable groups of citizens face significant barriers and functional limitations in basic actions of everyday life which hinder their ability to perform even routine daily activities [12] and often culminate in social exclusion. The condition of social exclusion assumes even greater significance when island contexts are considered. In such contexts, the mobility of individuals and the accessibility of the built environment are pivotal for achieving equitable development, which, in turn, fosters social integration, equality of opportunity and the mitigation of inequalities among analogous contexts [1]. The same categories, together with the place of residence, play a role in the digital exclusion from transport services [13]. According to these premises equity in transport accessibility has become a central research topic [14].

The contribution of new technologies, especially MaaS systems, to enabling vulnerable people to live better and more satisfying lives has been debated recently [2, 8, 15]. In recent years, the development of digital devices and the use of assistive technologies facilitates a significant change in the approach to accessibility. These innovations have enabled the creation of more transport alternatives contributing to a potentially greater equitable mobility for individuals of all social groups [8].

According to these premises, this paper tries to answer the following question: how can the potential support of MaaS models become effective?

The region of Sardinia, one of the two main Italian islands, is taken as a study context in which to explore the possibilities of an inclusive MaaS system to improve the accessibility of its inhabitants, with a particular focus on vulnerable groups. The research investigates if and how innovation in the mobility system can benefit the autonomy of this important segment of the population, and what factors can effectively increase the propensity of these people to travel and participate in community life.

3 Material and Methods

The reported research is part of the e.INS Sustainable Mobility project, whose main objective is to develop a MaaS system for Sardinian airports. The inclusion of "accessibility for all" criteria and requirements adds value and promotes integration at a social

level, leading to a "MaaS for all". This research is also part of the SMART3R-FLITS project which aims to evaluate the social inclusion of communities using land use and spatial data and methods. Lynott [16] argues that including the notion of universality into Mobility as a Service, when aligned with a commitment to livable communities, will provide a unifying framework to lead to more equitable, accessible and sustainable transport systems and corresponding living environments.

To develop MaaS solutions that ensure the right to mobility and access to urban opportunities for all groups of citizens, the authors have adopted a user-centred approach based on the concepts of "motility" [4] and "human capabilities" [17] with which to identify some enabling requirements to be included in the design of a MaaS for all platform. The authors are interested in measuring the capital of mobility of vulnerable groups and the elements that can enhance their capability to use the city autonomously.

With this aim, a multi-layer analytical methodology was developed combining spatial analysis techniques, geographic information system and direct survey.

A set of indicators to qualify individual space-time patterns, and mobility behaviour of vulnerable people looking for the barriers and enabling elements they encounter when travelling were considered. In addition, factors that most influence the propensity of these groups of users to use MaaS, were investigated in order to incorporate this knowledge into the design of an inclusive MaaS.

This information is key to measure the main constraints of these groups of citizens and to define some possible measures to be taken, with the support of MaaS systems, to overcome the main problems affecting their autonomy.

Operationally, the aim is to: (1) define the characteristics of the target population namely groups of people who encounter limitations in their mobility and, as such in their autonomy to take part in social life; (2) identify and verify the factors influencing travel autonomy; and (3) understand attitudes towards assistive technologies and new multimodal mobility models, exploring the main obstacles and enabling aspects.

With respect to the first target, a preliminary analysis of the socio-demographic trends in the region of Sardinia (based on data from the National Statistical Agency–ISTAT) and data concerning the use of available transportation options by people with disabilities was performed. This preliminary investigation shed light on the increasing process of ageing population and social vulnerabilities that characterise Sardinia island as a whole and, in particular its innermost isolated areas. To measure the mobility autonomy of people and their willingness to use assistive technologies, a survey was designed to answer the following questions:

1. Do autonomous travellers use assistive technology to plan and carry out their trips? If so, how often and for what activities?
2. Are there differences (structural and/or behavioural characteristics) between vulnerable people who use MaaS or similar travel planning models and those who do not?
3. What is the space of activity of people with mobility limitations? Does it differ by activity type? Do people who use travel planning and navigation apps have a wider space of activity? Do they make more complex trips? Do they use more sustainable modes?

The questionnaire addressed to vulnerable social groups examines individual patterns of daily mobility and associated transportation modes and socio-demographic profiles. Attention was given to the factors that influence the choice for each transport mode. Some of the variables used relate to service provision (availability, quality), others to spatial quality and accessibility, and still others to individual attitudes and preferences. Among the observed factors, there are some that can be improved by MaaS.

The whole analysis aims to derive some requirements that a MaaS for all must have with which to inform a Decision Support System (DSS) at the basis of the MaaS model.

3.1 Survey Methodological Framework

The analysis of the literature and theoretical positions developed by the mobility studies [4, 18, 19] lays the basis for the development of an operational method suitable for studying the mobility behaviour of vulnerable people and the barriers they encounter when travelling. Figure 1 synthesises the factors and variables considered.

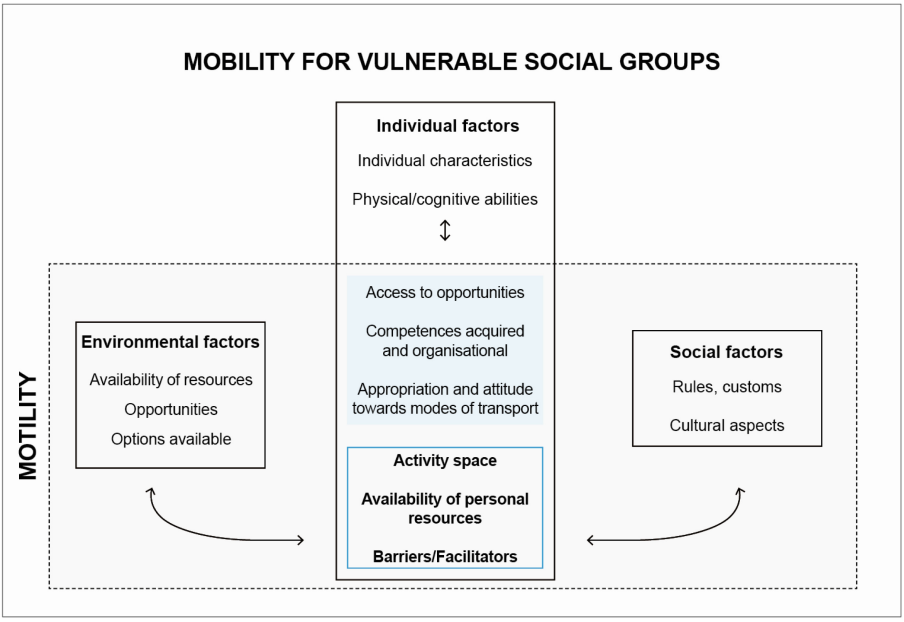

Fig. 1. Methodological framework for measuring the mobility capital of vulnerable social groups. Author: Sara Faedda

Access to opportunities and participation in social life are strongly linked to the capability of people to move. This capability is influenced by the environmental context and individual factors. Environmental and social factors include built environment configuration and land use as well as daily life organisation. Individual factors encompass socio-demographic features, and people's abilities, needs, skills, habits, attitudes and perceptions.

A structured questionnaire was developed to gather quantitative and qualitative data on three fundamental dimensions. The first part of the survey examined the socio-demographic characterisation of the target group. The second section is dedicated to the factors influencing travel autonomy by exploring people's activity space based on abilities and contextual conditions, while the third section aims to assess the attitudes of vulnerable populations towards assistive technologies and multimodal mobility solutions.

These last two sections of the questionnaire have been assigned a considerable amount of space due to their inherent nature. More specifically, the second part analyses the barriers that restrict the mobility of vulnerable individuals grouped into three main categories (i) Physical and environmentally-related barriers; (ii) Organisational and social barriers; (iii) Time and financial barriers. The analysis of these variables enables the identification of the principal impediments to autonomous mobility and thus to social participation and access to essential services. The third part explores the level of readiness to use technological aiding tools to mobility planning such as a planning platforms entailing: (i) respondents' familiarity with the digital tools currently available; (ii) willingness to adopt a multimodal approach to their travel; (iii) barriers and benefits they perceive in adopting such models.

The outcomes from these sections will facilitate a comprehensive understanding of the extent of acceptance of technological tools and the new forms of mobility, the main obstacles to the use of such mobility models, and will be instrumental in the development of a series of strategies and guidelines for a more inclusive and accessible MaaS platform.

4 The Sardinia Region Case Study

A comprehensive analysis of Sardinia's inland transport supply was conducted with the use of Geographical Information System (GIS), consisted in the reconstruction of the island's infrastructural assets, enriching the knowledge system informing the MaaS transport model, as well as the possible policies and strategies to be implemented at the territorial level in order to make this model operative.

While analysing public transport data, demographic data on the Sardinian population were collected and analysed. This allowed for the integration of socio-demographic aspects into the transport analysis, thereby facilitating a more comprehensive understanding of mobility needs across different territorial contexts. The population data were obtained from official statistics sources, such as ISTAT, and were essential in identifying factors such as population density, age distribution, and settlements patterns, which are crucial for designing a more inclusive and efficient MaaS system for Sardinia

4.1 Population Data

Sardinia, is the second largest island in Italy. The administration organisation of Sardinia is divided into 377 municipalities, 4 provinces (Sassari, Oristano, Nuoro, South Sardinia) and the metropolitan city of Cagliari. In 2024 the regional population exceeded 1.5 million inhabitants (ISTAT, 2024), representing 2.7% of the Italian population. The

population is geographically distributed across a vast network of small towns and suburbs, home to 20% of residents, and rural municipalities where 32.9% of the population resides. The remaining 17% live in cities. The island is also part of the National Strategy for Inland areas (SNAI) a programme aimed at addressing territorial marginalization in Italy [20]. According to the classification provided by SNAI [21], inland areas–categorised as intermediate, peripheral and ultra-peripheral on the basis of accessibility indicators–account for about 70% of Sardinian municipalities and host almost 37% of the population, a percentage comparable to that of southern Italy (Mezzogiorno).

4.2 Vulnerable Groups in Sardinia

In Sardinia, the phenomenon of social vulnerability presents distinctive characteristics, related to the demographic and socio-economic structure of the island. Of particular significance is the increasing ageing population, as reflected by the old-age index (Indice di Vecchiaia), defined as the ratio between the elderly (over 65) and the younger population (0–14 years), which according to the most recent statistics (ISTAT, 2024) stood at 266.6, indicating that for every young person there are 2.6 elderly. As shown in Fig. 2, the index illustrates a constant growth over a time period of over 20 years, indicating a progressive aging of the Sardinian population. This increase has become increasingly pronounced in the last 10 years, with the curve demonstrating a marked upward trend until 2024.

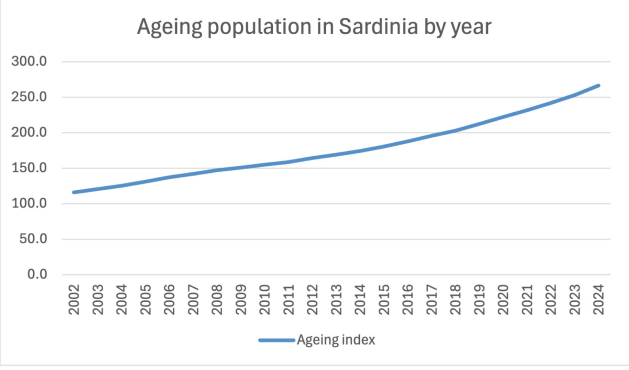

Fig. 2. Analysis of the temporal evolution of the old-age index in Sardinia from 2002 to 2024 (Data Source: ISTAT 2024). Author: Sara Faedda

The progressive ageing of the population is further highlighted through comparison of the percentages of residents aged over 75. The incidence of residents aged 75 and over compared to young people aged 0–14 highlights the strong demographic imbalance of the population in Sardinia. In particular, Fig. 3 shows a geographically opposite distribution: the municipalities with the highest incidence of elderly people, which are mainly located in the inland areas of central and southern Sardinia, tend to have a lower percentage of young people, who are more concentrated in the eastern coastal area, with a few exceptions in the inner municipalities.

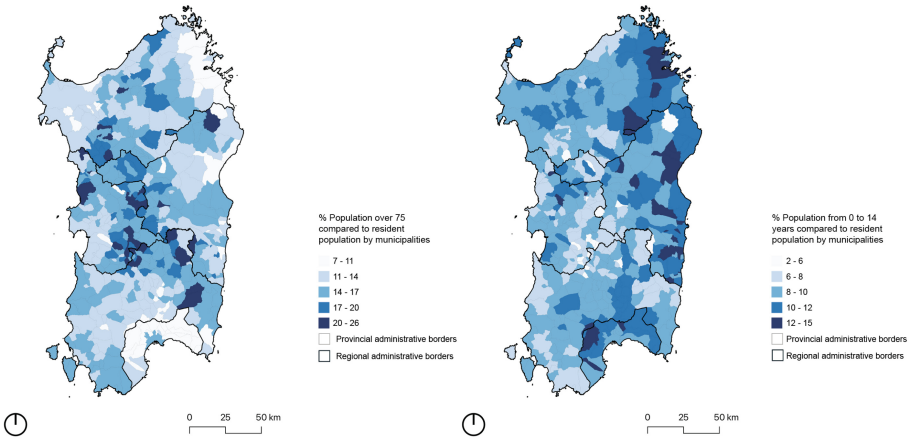

Fig. 3. Percentage of resident population aged 75 years and over and percentage of resident population aged 0–14 years. Author: Sara Faedda

In considering the characteristics of the population in the Sardinian context, and even more so the development of new technologies in the field of mobility, one is prompted to ponder the potential of a new mobility system based on new technologies to enhance the autonomy of the vulnerable population, such as the elderly. A substantial amount of research agrees that mobility innovations based on new technologies can lead to social exclusion of the elderly population due to digital exclusion and age, and that it is necessary to intervene through social policies and actions to reduce the digital divide [13]. This aspect was brought to light also by a recent study on the digital divide in Sardinia highlighted the challenges that arise as technology continues to advance for the elderly population [22].

Another important aspect of vulnerability in Sardinia relates to the population with disabilities. In 2024, the island has the highest percentage of people with disabilities, among the Italian regions, exceeding the national average of about 5% [23]. Specifically, the percentage of persons with disabilities on the island is 7.2%, with a stable time value for the male population (about 6% from 2009 to 2022), while for women there is an increase of about one percentage point, from 7.6% in 2009 to 8.4% in 2022 [23]. As stated in the previous section, it is also plausible that the elevated percentage is a consequence of the significant proportion of the elderly population who may be afflicted with disabilities associated with advanced age.

4.3 Public Transport Supply

Public transport in Sardinia is based on two main infrastructures: the railway and road network (Fig. 4). Extra-urban public transport is 70% managed by the regional transport company, ARST spa, an in-house company of the Sardinian Region [1] while the remaining 30% is entrusted to 50 private companies [24]. The rail transport service, on the other hand, is managed by two different operators: Trenitalia spa and ARST spa, the former managing a standard gauge network of 427 km connecting 45 stations. Of these,

only 12 provide assistance services for people with disabilities. This means that more than 2/3 of stations do not have adequate services to meet the needs of people requiring assistance.

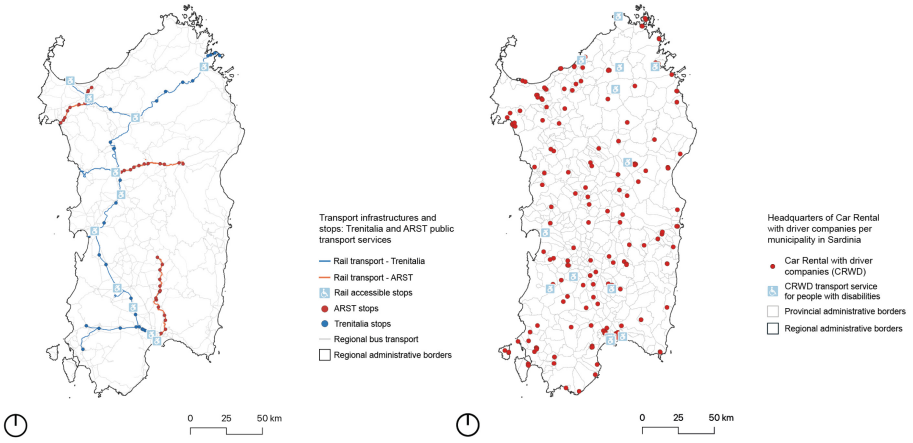

Fig. 4. Public transport supply in terms of infrastructure and modes in Sardinia. Author: Sara Faedda

In order to provide a comprehensive overview of the transport systems available in Sardinia, also with the hypothetical purpose of integrating different means of transport into a MaaS platform, in particular for the provision of these services to people with special needs, a mapping of the the Car Rental with driver was carried out, identifying their registered headquarters offices.

The Car Rental with driver service, known as "Noleggio con Conducente", it's a flexible service that compensates for the shortcomings of the scheduled public service in low demand areas. This service is widely spread throughout the region (Fig. 5) with around 220 officially registered operators [24].

This kind of collective transport service is similar to the Demand-Responsive-Transport (DRT) model in terms of its spatial and temporal flexibility and it's regulated by the National Law 21/1992. It represents a flexible solution in particular for areas far from the main urban centres, where the traditional public transport suffers from a limited number of daily trips especially over long distances and with low frequency by ensuring connectivity [25]. For the purpose of the research, data were also collected on the availaiblity of accessible transport services for people with disabilities (Fig. 5). In the regional context, 17 operators were identified that publicly offer such a service. The further development of the research aims to deepen this knowledge by completing the registration of individual licensed CRWD and conducting a direct survey to assess their readiness to become part of an integrated multimodal transport model, such as MaaS.

The Car Rental with driver (CRWD) service in Sardinia is a phenomenon that can be attributed largely to the island's strong tourist vocation, particularly during the summer season. This assertion is substantiated by an examination of the density of CRWDs per

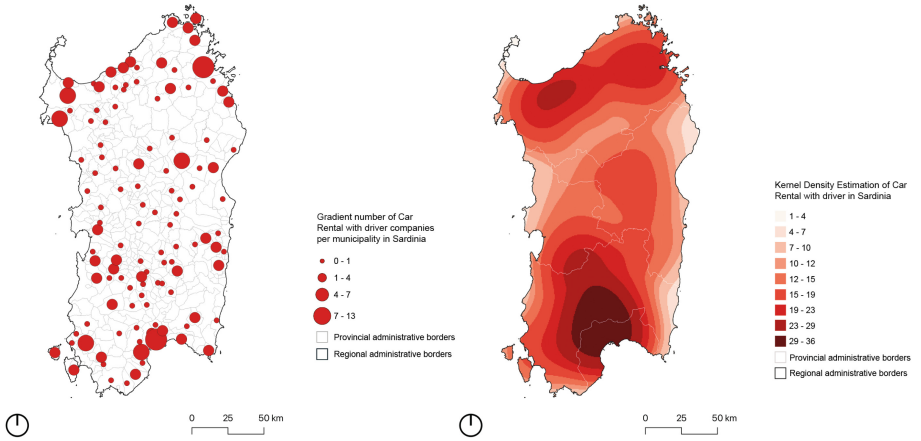

Fig. 5. Analysis of Car Rental with Driver companies in Sardinia—Kernel Density Estimation of Sardinian CRWD companies; R = 50 km/Cella Pixel = 500 mt × 500 mt Author: Sara Faedda

municipality. To obtain a more accurate representation of the phenomenon, the degree of concentration of each company per municipality was calculated in Fig. 5. The analysis revealed a significant concentration of CRWD companies in urban areas and tourist ones, as well as in the proximity of important transport hubs such as ports and airports. The cities of Alghero, Olbia, Cagliari and Sassari, for instance, exhibit a higher density of CRWDs, consistent with their function.

The initial overview of the spatial pattern results from the gradient analysis were confirmed by using the Kernel Density Estimation (KDE). This spatial analysis technique is based on estimating the density of a distribution of points in space, thereby producing a continuous density map representing the intensity of the distribution at each point in space [26]. In order to carry out this type of analysis, a 50 km bandwidth was chosen methodologically to highlight regional scale trends and provide a generalised view of the distribution of CRWD across the island.

As a result of the KDE, it reveals a relative widespread and homogeneous distribution of CRWD companies throughout the Sardinian territory, with clear concentration in the South Sardinia area, especially in the metropolitan city of Cagliari area, which has the highest density of CRWD services. The area of northern Sardinia shows a more diluted spatial distribution, from west to east, with peaks of concentrationin the cities of Sassari (west coast) and Olbia area (east coast), the latter being a city with a strong tourist vocation due to its proximity to the Costa Smeralda. By contrast, inner areas, demonstrate a lower density of CRWD companies in comparison to the rest of the regional territory, with the exception of a few concentration points near the Ogliastra area, reflecting a weaker service presence.

Public Transport for People with Limitation

The analysis of the transport services offered in Sardinia led to the identification of a

public service, financed by the Autonomous Region of Sardinia, which provides door-to-door transport on request. This service, known as "AmicoBus", is intended to complement the public transport service and is in fact a door-to-door service, on a 24 h pre-reservation, for people with special needs. The service is currently characterised by a relatively limited operational coverage. In the northern region, its operation is confined to the city of Sassari, a service initiated by the Public Transport Company (ATP), with a service radius of 12 km [27]. In the southern region, the service is operational in five of the eight municipalities in which CTM operates for LPT (Cagliari, Quartu Sant'Elena, Monserrato, Selargius, Quartucciu), within the area encompassed by the SS 554 motorway [28].

The service is intended for citizens who, in the reference year, did not purchase tickets benefiting from regional fare concessions and who belong to one of the following categories: people with disabilities as defined by Article 3 of Law 104, Civilian invalids, as defined by Article 1 of Law 118; Non-self-sufficient elderly individuals over the age of 65, and others with ascertained psycho-physical limitations, assisted by social, municipal or local health authority services.

4.4 Use of Transport by People with Disabilities

Despite the numerous and varied factors that determine a greater vulnerability of one population over another (including physical and cognitive conditions, as well as disadvantaged socio-economic conditions), this article will primarily focus on persons with limitations in their autonomy of movement (due to disability or old age). In particular, an analysis was conducted on available ISTAT data [29] concerning the utilisation of a range of transportation methods. These included rail, inter-urban and urban public transport, as well as automobile usage by drivers. In accordance with the categorisation employed by ISTAT, the term 'persons with limitations' is employed in this article to denote 'persons with disabilities', with the additional specification of the degree of limitations. The categories indicated are based on the Global Activity Limitation Indicator (GALI), an instrument which measures long-term disability [30]. The GALI was developed as part of the implementation of a broader set of instruments which have been recommended for introduction into European surveys [31].[1]

In order to focus attention on the provision of inclusive mobility services that meet the needs of people with disabilities, an analysis was conducted using ISTAT data (National Statistical Agency) on the use of public and private transport for people with severe,

[1] This indicator has three levels in order to allow more accurate differentiation of severity with respect to functional limitations:

1. Severely limited (severe limitations): Individuals who present with this condition typically require assistance from others to perform activities of daily living.
2. Limited but not severely: Individuals who present with this condition typically do not require assistance from others. In cases where assistance is provided, its frequency is typically less than once a day.
3. Not limited at all: Usual activity can be carried out without difficulty or that a possible limitation of the activity has not been in place for at least 6 months.

less severe and no limitations. The analysis revealed that data on the mobility of persons with disabilities at a national level indicates that only 14.4% use urban public transport, compared to 25.5% of the rest of the population. A similar trend is observed in Sardinia, where 14.55% of persons with disabilities use urban public transport.

The low percentage of accessible[2] stations, is consistent with data on the use of trains by people with disabilities: Fig. 6 shows that, in 2023, more than 86% of them didn't use the train as a mean for their journeys.

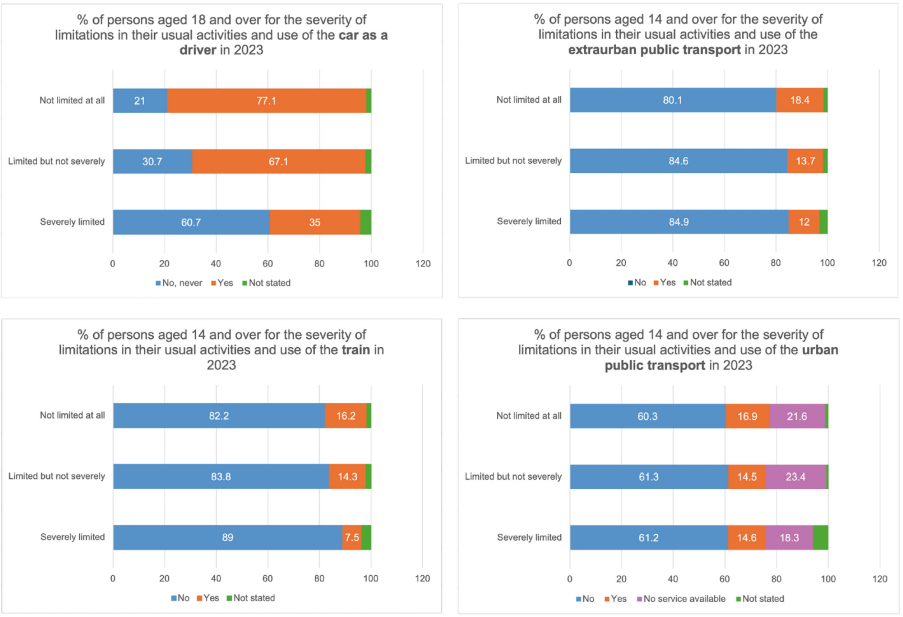

Fig. 6. Overview of the use of different modes of transport in Sardinia by people with disabilities in 2023 (Data Source: ISTAT, Disabilità in cifre 2023). Author: Sara Faedda

The percentage of those who do not use the service is slightly higher (61.2%) than in other categories; this data may suggest restricted accessibility owing to physical or logistical barriers, probably more marked for people with significant limitations, thereby complicating their use of public transport [32, 33].

For some categories of people with disabilities, there is a lack of urban public transport services in their residential areas or at accessible locations: 18.3% of people with disabilities have no access to urban transport services. The percentage of people with disabilities reporting insufficient accessible services tailored to their needs is greater among those with severe limitations (18.3%) compared to those without limitations (21.6%). The data concerning public transport use is particularly noteworthy in extra-urban contexts: over 80% of the population, regardless of disability severity, does not

[2] Accessibility in terms of the possibility of requesting assistance, it is assumed that at least the stations marked as accessible are physically accessible.

utilise extra-urban public transport. This indicates that the problem pertains not solely to disabilities and individual functioning, but additionally to the overall appeal of the service.

The examination of the data supplied by ISTAT for the year 2023 indicates that access to public transport, both urban and extra-urban, in Sardinia is significantly problematic for people with disabilities, regardless of severity, as well as for those without disabilities. This signifies an insufficiency of appropriate mobility services, particularly in internal regions, as well as infrastructural issues. From these considerations regarding the data and the literature analysis on various transport planning approaches, the centrality of the accessibility issue becomes evident.

Over the past decade, numerous schools of thought have re-evaluated transport planning methodologies by prioritising accessibility as a crucial factor for ensuring individual participation in social life, supported by various scholarly references [34–37].

5 First Insights for a MaaS for All

Mobility is a fundamental human capability and a pivotal factor for social inclusion. Despite the heterogeneity in needs, habits and behaviours, it is imperative to recognise that all individuals have the right to be mobile in space.

Today, mobility is increasingly becoming a digital reality, as innovations in communication technologies and data sharing transform the possibilities of movement [38, 39]. This transition has both advantages and disadvantages.

On the one hand, the integration of technology and digital tools into everyday life has proven useful for many people in carrying out their daily activities. On the other hand, innovation in transport systems, much of which relies on new technologies, can exacerbate the digital divide between groups of citizens, by excluding those who are not familiar with these tools. For example, while digitalisation of transport systems is an empowering measure for certain groups of citizens, for example those with sensory disabilities, it can also be a barrier for others, such as the elderly.

Therefore, the provision of inclusive, innovative mobility services asks for an exhaustive knowledge of the characteristics of different social groups and their diverse attitude towards transports and the use of the digital platforms [2, 13, 40, 41].

In other words, concomitant with technological advancement, social aspects are of significance in the propagation of urban mobility innovations [39].

The article proposes a methodological pathway for building the knowledge base for the development of a MaaS for all system.

The way everyday mobility contributes to the enhancement of individuals' freedom of being and doing what they have reason to value [17], and how innovative transport systems may extend the mobility capital are explored giving particular attention to vulnerable social groups as they face limitations in their participation in social life. The region of Sardinia was selected as testbed due to its structural characteristics and socio-demographic dynamics which suggest a reflection on the benefits and obstacles provided by MaaS.

Scholars identified shared mobility and its integration with conventional public transport into multimodal solutions supported by MaaS platforms among the most challenging solutions in urban mobility [42–44].

Consequently, the proposed methodology allows to identify the factors that influence the acceptance of emerging mobility solutions, with the objective of generating insights that can inform the development of customised on-demand transport solutions tailored to the needs of users. In this manner, the present study contributes to extending the body of knowledge about the requirements of digital customised transport platforms.

Although the research is still ongoing, the following preliminary findings from the literature can be shared to inform the development of a MaaS for all.

Firstly, the principles of Design for All need to be incorporated into all stages of the planning and design process of new sustainable mobility services. Accordingly among the possible factors to encourage the use of MaaS by vulnerable people, the following are key [16]:

- Technological accessibility of information, by ensuring that platforms and apps comply with the guidelines on accessibility of digital content;
- Variety and quality of mobility services, starting with the implementation of on-demand transport services provided by qualified operators and vehicles suitable for the transport of assistive devices (e.g. wheelchairs) and ensuring that the algorithm takes into account the increased loading and unloading time;
- provision of users' multichannel communication solutions and adequate customer support. People who are not familiar with technology (the elderly, people who do not have PC, smartphones, mobile device or bank accounts and online payment instruments), need the provision of multiple options of communication and payment including field staff, ticket offices and third-party resellers in addition to smartphones which ensure customer care 7 days a week;
- redesign of digital devices and accessibility of information interfaces (online platforms, smartphone apps, totems, information panels) to make them more user-friendly and intuitive, as they are often inadequate in terms of practical functionality due to the reduced physical and sensory efficiency of certain groups of users [22].

Based on these conditions, the next step in the research is to disseminate the questionnaire also thanks to the involvement of a number of institutions and associations active in the territory, including the AISM (Italian Multiple Sclerosis Association) and the University of the third age, which will allow us to reach as many people as possible.

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