UNIVERSITY OF MALTA

Institute for Sustainable Energy

MSc. Project

SHARED MICRO-MOBILITY SERVICES: A SUSTAINABILITY ASSESSMENT OF THEIR USE IN MALTA

by

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A dissertation submitted in partial fulfilment of the requirements

of the award of Masters in Science in Sustainable Energy

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ABSTRACT

Shared micro-mobility services in Malta, such as bicycles, e-bikes and e-scooters, were analysed in this dissertation. Literature shows that shared micro-modes of transport pose several benefits, such as reduced traffic congestion and the promotion of an active alternative mode of commuting, posing cost-effective, health and social benefits. They are ideal for last mile trips and work extremely well when properly integrated with the transport system, particularly the road infrastructure and public transport systems. Shared micro-mobility services reduce the energy demand and have the potential of reducing carbon and greenhouse gas (GHG) emissions on local roads. Although in 2016 shared micro-mobility services were introduced in Malta, these abruptly halted their services. Thus, the aim of this thesis was formulated as follows: To perform a sustainability assessment on shared micro-mobility services in Malta, to understand their sustainability advantage, the reasons why they stopped operating, and to make recommendations for their inclusion in sustainable transport locally. The methodology to gather data was semi-structured interviews with 18 key stakeholders of transport in Malta. A simplified sustainability assessment and policy review were also conducted.

Results show that the majority of participants perceived them as sustainable and that there needs to be a competitive advantage over other modes of transport (particularly the private car), the provision of safe infrastructure and better enforcement. Participants also claimed that the main reasons why they left was due to abuse, chaos, no discipline (especially amongst e-scooter users), vandalism and lack of safety towards pedestrians and other road users; with 40% of the respondents agreeing with these services halting operations.

The Maltese government is looking towards the future, providing incentives for the use of personalised e-bikes and e-scooters. However, sharing services are still not being pushed to reintroduce them. Although private micro-vehicles may reduce the abuse, irregularities and dangers to self or pedestrians, they do not eliminate them. Shared services still have the potential to provide a cheap, flexible and convenient alternative to commuting, and its potential (considering Malta's size) should not be ignored. Key concluding recommendations include the need for pilot projects, an enhanced regulatory framework and enforcement, more awareness and acceptance, improved public transport (bus/ferry) and integration, and the provision of safe infrastructure.

ACKNOWLEDGEMENTS

I would like to express my utmost appreciation and thanks to Dr Thérèse Bajada, my supervisor, and Dr Suzanne Maas, my co-supervisor, with whom I have worked closely throughout the course of this project.

I must express my gratitude and give special thanks to each of the 18 stakeholders who participated in the interviews of this project and to whom I am grateful for their knowledge and experiences passed on, benefitting the outcome of this study.

Finally, I must express my great appreciation and thanks to my mother and father, Janice and Anthony Psaila, for their constant support and encouragement throughout the course of this project, my engineering career and my life.

Dedicated to my soon-to-be wife

Amy Schembri

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LIST OF ABBREVIATIONS

Al	Aluminium
A-S-I	Avoid – Shift – Improve
BSS	Bike Sharing Service
CO_2	Carbon Dioxide
EU	European Union
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GWP	Global Warming Potential
ICE	Internal Combustion Engine
KPI	Key Performance Indicators
LCA	Life Cycle Analysis/Assessment
NGO	Non-governmental Organisation
NSO	National Statistics Office
POI	Point/s of Interest
PPP	Public Private Partnerships
SOV	Single Occupancy Vehicles
SUMP	Sustainable Urban Mobility Plans
TM	Transport Malta
UREC	University Research Ethics Committee
US	United States

Chapter 1: Introduction

1.1. Transport Problems Today

Transport is needed to move people from several origins and destinations, which include residences, commercial areas, workplace, hospitals, leisure areas, schools and universities [1]. Moving people around requires several modes of transport, such as privatised car use, public transport, active transport or shared services, which also require significant amount of energy. The energy demand in the transport sector is currently responsible for one-third of the total energy consumption in the European Union (EU), and for around one-fourth of the EU's greenhouse gas (GHG) emissions [2] [3] [4]. Energy is needed to power the actual mode of transport, be it a car, bus or electric bicycle. Energy is also needed to manufacture these modes of transport, and it is also involved in the logistics incurred to distribute these modes to their destination of use. Energy is also required for infrastructural projects required for these modes of transport, such as roads or fly-overs. Finally, energy is needed for maintenance and cleaning purposes as well as to sustain their operating, monitoring and technological systems [1].

Road transport in urban settlements, such as cars, buses, trucks and others, pose several challenges and impacts on the environment, on society as well as on an economic point of view. Negative impacts on the environment include air pollution and the release of GHG emissions as a result from the burning of fossil fuels in combustion engine vehicles [2]. The demand for fossil fuel itself also poses environmental concerns due to resource depletion as well as energy required to extract and transport such fuels [3]. Air pollution also results from dust particles transported by the vehicles themselves as well as eroding tyres and brake pads [5]. Increasing use of private cars results in increasing demands for infrastructure and parking spaces, which leads to further construction of roads and environmental deterioration, disturbing habitats and ecosystems [1]. Noise pollution, from car engines and large trucks passing by, also disturbs the environment and natural habitats [6].

Impacts on society include traffic congestion, noisy streets and parking problems, which may lead to road rage and dangerous driving [1] [6]. Busy roads and large road infrastructure projects, such as fly-overs, are a hindrance to localities and can result in

disturbances in the layout of settlements and divisions in communities [7]. All these problems ultimately lead to a deterioration in the quality of life of a locality or country [3]. Several transport systems are also discriminatory towards those outside the use of private cars; either those who cannot or do not want to drive [1] [8]. This leads to problems related to sharing the road for public transport services or other modes of transport, such as people travelling by bicycle or on foot [1] [9]. Chaotic traffic patterns with high use of private cars and motorcycles may lead to an inadequate public transport system. Moreover, due to authorities giving high priority for the infrastructure for private cars, accessibility problems can result for several pedestrians or other road users due to insufficient infrastructure to cross busy roads or enough space to walk comfortably and safely [9]. Unfortunately, this leads to more people preferring to own and use private vehicles, further aggravating the mentioned problems [8]. Single-occupancy vehicles (SOV) are another issue attributed towards the use of private cars. According to the European Commission, private vehicles have an average occupancy rate of less than two. In fact, many times, vehicles designed to hold around five persons, are only driven by one person and the other seats are left vacant. These take up a lot of wasted space on roads [10]. There are also impacts on society's health due to air pollution, leading to respiratory diseases and infections, such as asthma.

From an economic point of view, poor health conditions and dangerous driving lead to more medical treatments and hospitalisation costs. Additionally, traffic congestion leads to longer trips, wasted time and wasted energy. Increased demand for private car usage leads to more infrastructure costs and moreover, the upkeep, maintenance and upgrade of such infrastructure poses additional costs on authorities and taxpayers [8]. These costs can be somewhat "hidden" however they do accumulate [6] [4]. In fact, according to Transport Malta, the accumulated costs associated with congestion, air and noise pollution, climate change and road crashes as a result from commercial and private vehicles has been projected to increase to €579 million by 2025 [11].

1.2. The Need for Sustainability in Transport

These transport problems, especially in the urban road landscape, highlight the need for sustainability in the transport sector. Sustainable transport resolves some of the problems associated with transport by implementing the Avoid-Shift-Improve (A-S-I) approach, demonstrated in Figure 1 [1] [12] [13]. This approach provides a hierarchy of priorities and solutions to the transport problems.

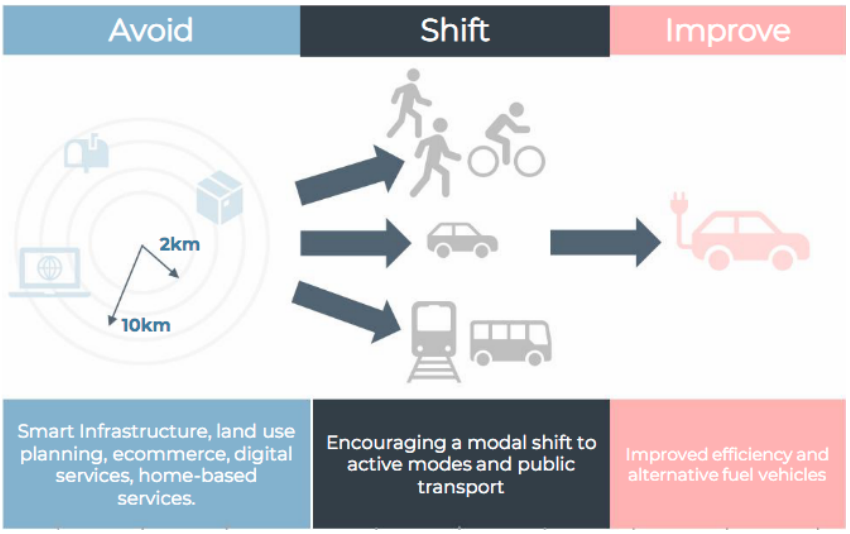

Figure 1 - Avoid-Shift-Improve Strategy *[12]*.

As can be seen in Figure 1, focus to avoid the need to require transport, that is to avoid the need to actually make trips, should be prioritised. This is implemented by promoting a mixed land use or substituting trips through online communication and e-commerce solutions [14] [13]. Secondly, a shift towards more sustainable, more energy efficient and less energy-intensive modes of transport should be implemented. Commuters should opt for active modes such as walking and cycling, public transport and shared mobility services [14] [13]. Finally, within a long-term approach, scientific advances and innovation should strive to continuously improve the sustainability of all types of vehicles and their fuel technologies, into more carbon-efficient vehicles and electric vehicles powered by renewable sources of energy, decreasing their energy and carbon footprint intensities [14].

This shift needs to overcome the challenge of ever-increasing demand for private vehicle ownership [12]. In Malta, according to the National Statistics Office (NSO), private car ownership and dependence has never been higher, with the stock of all licensed motor vehicles standing at 440,163. Out of this, 74.4% were passenger cars (327,481) [15].

Moreover, also according to Transport Malta (TM) 74% of all trips are done by private car [11]. Private vehicles present clear advantages over other modes of transport and options available to commuters. The three key attributes for its selection are flexibility, comfort and availability, primarily due to their nature and spatiotemporal location [16]. However, despite these advantages, it's widely known that privately owned vehicles are one of the least sustainable modes of transport. According to the European Commission, private vehicles spend around 92% of the time parked, and when they are moving, their average occupancy rate is 1.5 persons per vehicle, per trip, despite able to hold around four passengers as well as a driver [10].

Promoting a modal shift towards more sustainable modes of transport is one of the guiding principles of the National Transport Strategy 2050 for Malta. These include the promotion of public transport, active modes of transport, such as walking and cycling, as well as shared mobility services, such as car sharing services and shared micro-mobility services, where the latter is the focus for this dissertation [17].

Shared micro-mobility services provide several advantages and are more sustainable than the overbearing use of privatised fossil-fuel cars in Malta [1]. Literature shows that shared micro-mobility services have a lower energy consumption, higher energy efficiency, lower carbon footprint, amongst other benefits [3]. However, despite being identified as sustainable and highlighted in Maltese policy documents, services, such as Nextbike shared bicycles, as well as Bolt and Bird shared e-scooters, left the Maltese Islands in recent years, which is contradictory [18] [19] [20].

Hence the aim of this dissertation is as follows:

To perform a sustainability assessment on shared micro-mobility services in Malta, to truly understand their sustainability advantage, to understand the reasons why they stopped operating in recent years, and to make recommendations for their inclusion in sustainable transport locally.

1.3. Dissertation Overview

The concept of shared mobility, shared micro-mobility services and alternative modes of transport are discussed to understand their sustainability impact and contribution towards reducing the energy consumption of the transport sector. This is done through a literature review, written in Chapter 2, which demonstrates the state of the art on these innovative trends and modes of transport. Following this, a description of the methodology is written in Chapter 3, which describes the research design and case study, the formulation of the research questions of this study, and methods of gathering data. Results are then provided in Chapter 4, while a discussion is written in Chapter 5, consolidating the knowledge gathered throughout this dissertation. Conclusions are finally drawn up in Chapter 6.

Chapter 2: Literature Review

This chapter documents the literature review conducted for this study. The literature review outlines the topic at hand, the work conducted by previous studies and overall knowledge and state of the art of the literature on shared micro-mobility services.

2.1. Shared Mobility Services in Transport

The 21st century has seen ever-increasing concerns related to the environment, social problems, degrading quality of life and the ever-increasing use of the private car, which has led to the rethinking of urban mobility. The concept of shared mobility started with the alternative solution of short-term rental systems of vehicles where a new sharing economy emerged that enabled people to access goods and services without ownership. Shared economy, and in turn, shared modes of transport, promote a more sustainable consumption model, with beneficial economic, social, and environmental impacts [3] [21].

Shared modes of transport form part of the second step, the *Shift*, in the Avoid-Shift-Improve model for sustainability, providing an alternative to private vehicles, as also shown in Figure 1 [6]. Shared mobility modes of transport include shared scooters, shared bikes or e-bikes, shared mopeds, ride hailing taxis or mini-buses and shared cars or electric vehicles [22]. These make use of mobile applications and digital platforms to find and access shared vehicles, as well as perform payments through users' credit cards [23]. Shared modes of transport encourage a more multi-modal form of commuting. In fact, shared modes can be used as the first- or last-leg of journeys made with public transport to reach one's final destination [6] [24].

Following access to shared vehicles, users are allowed to use the vehicles to commute from one destination to another. Once arriving at their destination users are able to park their vehicles and complete payments. Shared mobility services are generally either station-based or free-floating (dockless) [6] [2]. The former has specific docking stations or reserved parking for bicycles, scooters or cars, while the latter allows users to park more flexible, usually still within a series of set perimeters and instructions [6]. Information is easily shared between services and users through the mobile applications, including personal information (such as age or license) as well as helpful information on availability, new schemes and offers and training tools or tips on how to use such modes properly [23] [24].

2.1.1. Benefits of Shared Modes of Transport

Shared modes of transport have the potential to reduce traffic congestion and reduce the need for parking spaces, since a single vehicle is being used by numerous drivers throughout the day [3]. Moreover, some shared modes of transport such as e-scooters, e-bikes and mopeds or motorcycles are physically smaller than cars and hence take up less space for parking and on the roads [3] [25]. In addition, a case study in France showed that the occupancy rate of shared cars is higher (between 2.5 and 3.5 persons per car), than that of privately owned cars - which have a tendency of having a low average occupancy rate (around 1.5 [10]), many times with a single occupant [26]. This leads to a decrease in the total number of vehicles on the roads and in turn, traffic congestion levels, air pollution, carbon and greenhouse gas emissions are also decreased, benefitting the environment and society. Hence, traffic efficiency increases, and unnecessary external costs are reduced [3]. Interestingly, shared mobility is enabling the number of private vehicles per household to decrease. It is also creating a new mentality where users renounce ownership of a vehicle and use shared transport services according to their convenience [6].

For the user and individual, shared mobility provides certain benefits as well. First and foremost, they offer a flexible and convenient service where one can use as needed. Such services are significantly cheaper than owning private vehicles. In the case of bicycle sharing, users are able to exercise, benefitting one's health. In the long run, as shared mobility becomes more popular, the number of private cars decrease and traffic congestion decreases, the user also saves time as they will not get stuck in traffic or waste time finding parking [6] [24] [25].

2.1.2. Requirements of Shared Mobility

With the benefits shared mobility provides, an urban landscape's efficiency, the quality of life, competitiveness, attractiveness and social equity improves [3]. Shared mobility, however, should not be considered as a stand-alone service, but as one that is fully integrated into the urban transport landscape, ensuring efficiency with respect to all three pillars of sustainability [27]. Businesses, governments and society should strive to achieve a common objective for sustainable transport [3]. Integration include amalgamation amongst infrastructure, different modes of transport and networks is achieved through single ticket systems, digital platforms and real-time information, harmonious schedules, availability of vehicles, and proper location of vehicles [3] [27].

Future advances in vehicle electromobility, automation and connected vehicles further enhances the sustainability within the transport sector. Integration through access to other facilities, such as parking or showers at destinations also enhances the more active shared services, such as bicycle or scooter sharing, as mentioned by Félix et al [27].

Changes in society have led to the integration of shared modes of transport into the transport sector. Life has become so fast, that society looks for quick easy solutions in all aspects, including transport [3]. Digital platforms, the emergence and advances in mobile technology and smartphones, the mass use and increased access of the Internet, automated systems, artificial intelligence and advances in GPS technology, have all contributed and facilitated the creation of shared mobility as an integral mode in the transport sector [3] [23].

To ensure an effective scheme of shared mobility, according to Ditta et al, the service must be inclusive, accessible and citizen-oriented, such that the whole population, from all socio-economic backgrounds, regardless of levels of ability, have access. Such a service also needs to be safe to users, other road users and pedestrians. Such services must also embrace innovation, promoting the use of new technologies able to facilitate and enhance the service. To achieve sustainability, shared modes of transport need to be environmentally friendly, economically viable and efficient. They must also be socially just and support society's health through active commuting and supporting communities. Such a service also needs to be equitable and non-exploitative; having fair prices, supporting decent work conditions and offering appropriate competition for other transport sector workers. It is important for the proper implementation of a shared mobility service to have a good regulatory framework in place, to be able to adapt to continuous scenario changes and technological advances [28].

To ensure the accessibility and availability of shared modes, they tend to be found in the inner-most ring of a city and in urban settlements [29]. In fact, this tallies with Krykewycz et al., where higher population density areas, indicating residential areas, tend to be trip origins, while areas with higher job density, retail density, tourist attractions, parks and leisure locations tend to be trip attractors [25] [30]. Hence, shared modes of transport are found in areas with a high land use mix [28].

2.2. Shared Micro-Mobility Services in Transport

Shared micro-mobility services are a branch of lightweight shared mobility services discussed in Section 2.1. of this literature review [31]. These services include bicycle, e-bike and e-scooter sharing modes of transport [6]. While these micro-modes of transport maintain some of the characteristics and benefits of shared modes of transport discussed previously, they provide particular characteristics and advantages as well [3]. These are discussed in this section of the literature review. Shared micro-mobility services shall be the focus of this dissertation, as they are an innovative alternative method of commuting from the bulky methods of commuting used in Malta, such as public transport, combustion engine cars or electric cars. In fact, shared micro-mobility services such as e-scooters and bike sharing systems (BSS) have grown and evolved significantly in the past decades and have become a common feature in modern cities in Europe, providing a low-carbon, flexible mode of transport [32]. In fact, between 2018 and 2019, e-scooter use in the United States (US) increased by 120%, from 38.5 to 88.5 million trips in 2019. On the other hand, bike sharing services increased by 40% in the last decade, reaching 40 million trips in the same year [33].

2.2.1. Shared Micro-Mobility Services in Malta

Nextbike Malta introduced a bicycle sharing service in 2016, with 58 stations and over 400 bicycles, with the majority of bicycle stations being located around central urban towns including Sliema, Gżira, Msida, St Julian's as well as the University of Malta [6] [34]. Other localities such as St Paul's Bay, Buġibba, Mellieħa, the Airport and Marsascala also had a couple of stations. Tallinja Bike, an initiative by Malta Public Transport, inaugurated a small e-bike sharing system in Valletta in the summer of 2018, consisting of 40 electric bicycles spread across three stations in the city, and also has two stations in Gozo [25] [34].

Bolt and Bird shared e-scooters were introduced in Malta in 2019 [35]. Since then, an estimate of 5000 scooters, between the two companies, were being operated on the islands [20]. However, Nextbike abruptly left Malta in 2022 [18], and Bolt and Bird e-scooters were banned, from the 1st March 2024, making Malta the first European country to completely ban shared e-scooters [19] [20], begging the question as to what were the reasons that led to this situation on the islands.

2.2.2. The use of shared-micro mobility services

How shared micro-mobility services are used

As mentioned previously, shared micro-mobility services make use of a mobile application for users to track and find these modes of transport on the roads [25, 3]. Unlike motorcycles or cars, these can be found in promenades, pavements, public gardens and pedestrianised zones. They can either be found individually, depending on where a previous user left the vehicle (as shown in Figure 2), or they can be found in an allocated docking stations – many times there will be several vehicles in one parking area (as shown in Figure 3) [6].

Figure 2 - Stand-alone E-scooter *[71]*

Figure 3 - Nextbike shared bicycle parking station in Malta *[37]*

Users make use of the mobile application where they subscribe and add personal details, including age and bank card details [23]. To access the vehicle, they scan a QR code on the vehicle, and the system unlocks the vehicle if it's automatic or provides a code to unlock a lock (in the case of the bicycle sharing service shown in Figure 3). Once the vehicle is unlocked and ready to be used, a timer starts [24] [25]. Users are then allowed to use the vehicle to travel to their required destination. In some vehicles, smart technologies allow systems to track the route one takes and monitors their speed and usage [24]. The speed of shared micro-mobility services does not exceed 25km/hr [36]. When the user arrives at their required destination, either at allocated parking bays or at their own preferred stop – depending on the type of service, the user leaves the vehicle, inputs in their mobile application that they're stopping their commute, the system locks the vehicle in place (once again either automatically or otherwise), and the user pays the

fee of the service through direct bank card transaction [24]. In terms of payment, the services in Malta either had a pay-as-you-go scheme (with minute or hourly rates), or a weekly, monthly, quarterly or annual membership [3] [37] [35] [25] [32].

Where shared micro-mobility services are used

Like shared mobility services, shared micro-mobility services are usually found in cities and the urban environment. They are located and can be found in areas where there are numerous residences, commercial and leisure facilities, such as cafes, restaurants, beaches or promenades [29]. Cities also have a larger percentage of tourists and foreign population, who may utilise shared modes of transport instead of purchasing their own vehicle [3]. A study by Maas et al. mapped the BSS stations in Malta, and as noted such stations are within very close proximity to commercial and leisure facilities. These urban areas include areas such as Sliema and St. Julian's [38].

Most shared micro-mobility research was focused on large cities across the globe, but few studies have looked at the use of shared micro-mobility services in more remote areas, towns and rural villages. Although such cities in Malta have long spacious promenades along the coast which are regularly used by active commuters, there is still limited cycling infrastructure or networks in these areas, where the shared micro-mobility services were primarily operational [25] [38].

When shared micro-mobility services are used

According to O'Brien et al., the main uses for BSS are for leisure, sightseeing, recreational purposes, commuting or running errands [39] [25]. In addition, according to Fishman, users who use BSS for commuting purposes tend to become subscription members with the service provider due to a more frequent use, while those using BSS for leisure or sightseeing purposes tend to be more casual – in fact many of these users also include tourists [40] [25].

Although in principle, warm and sunny weather has a positive effect on levels of cycling, temperatures above 30◦C, hot summers and fear of arriving at a destination sweaty are also other barriers for such active modes of transport [38]. However, rainfall also may act as a barrier. In contrast, an analysis of BSS use in Seville and Dublin, showed that both hot and sunny weather, as well as rainy and windy conditions were positively associated with frequent BSS use, indicating that weather conditions do not negatively affect the BSS use of frequent users in these cities [41].

People use bicycle sharing services for a trip duration ranging between 10, 30 or even 60 minutes [42] [43]. On the other hand, the average length of trip in the US for e-scooters is around 1.6km, covered in 20 minutes [33], while in European cities the average trip length is around 1.8km, for around 15 minutes [44]. The usage fluctuates daily mainly due to weather conditions and specific days of the week reaching 6.4km/day, up to 12km/day [31]. For e-bikes, average distance was 2.5 km and 3.06km resulting in a daily mileage of 8km/day to 24.5km/day [31]. According to Krauss et al., the majority of trips of shared e-scooters is during the second half of the day, with the highest usage observed between 3pm and 7pm, peaking at 5pm [45].

Shared micro-mobility services users

From case studies conducted in Malta and Limassol, Cyprus, the main users of shared micro-mobility services were between 18-24 and 25-34 years of age [38]. Interestingly, in an analysis of bicycle sharing system (BSS) in Seville and Dublin showed that most respondents were not used to cycling before starting to use BSS. This suggests that knowing or not knowing how to cycle does not affect whether people find such services attractive [38].

Additionally, in Malta, more than 50% of shared micro-mobility users were found to be foreign, most of these foreign users were also found to be permanent residents [38] [41]. In contrast, a report in France showed that only one in four e-scooter users were non-residents, showing a greater percentage use amongst residents (75%) than in Malta (50%) [44]. In 2016, Fishman et al, determined that the main users for shared micro-mobility services are white, male, workers and having high income [40]. There seems to be a gender gap who use shared micro-mobility services with the share of male scooter users amount to 66% in French cities [44] and 75% in Vienna [46].

Other users of shared micro-mobility services may be too young to drive, or do not have access to a private car, while other users include those who want to avoid traffic congestion and parking problems [47].

Although shared micro-mobility services tend to be used by persons living and working within the urban landscape, other users also said that although they do not live or work within the catchment areas of shared micro-mobility services, they still utilise such modes of commuting in centrally located areas [6]. This suggests that such services are a convenient as part of a commute, such as for the last-mile travel or to run errands [6].

2.2.3. Carbon Footprint and Energy Use of Shared Micro-Mobility

Several studies consolidate the environmental impact, carbon footprint and energy use by defining values for the entire lifetime of the products. These findings for shared micro-modes of transport, for bicycles, e-bikes and e-scooters, are presented in this section of the literature review.

Bicycle and E-bike

A study in China compared the Carbon Dioxide (CO_2) emissions in 2021 for a full year of four modes of transport, including the car, subway, bus and bicycle, the latter being the only micro-mode compared in this analysis, amongst five towns. Results, shown in Figure 4 clearly show that the car has the most amount of CO_2 (in kilograms) in all five towns, having an average of 1.3 million kg, while the bicycle has the least, with an average of 10,000 kg, highlighting the reduced environmental impact of a micro-mobility mode of transport in comparison to the private car. Other modes of transport such as buses and subways also have a lower carbon footprint than that of a private car [48].

Sample data of CO_2 emission from the four transport modes (unit: kg).

Township ID	Car	Subway	Bus	Bike
440785104	1,094,086.526	180,811.492	456,704.142	9056.764
440785108	1,357,566.371	213,567.418	619,698.667	10,232.108
440785106	1,395,204.313	232,020.191	574,815.140	9725.901
440785102	1,130,591.792	180,697.816	540,276.656	11,337.944
440785100	1,642,765.412	257,239.415	734,362.517	11,471.460

Figure 4 - Table showing CO_2 emissions from four transport modes in China (in 2021) [48]

Another study by D'Acierno et al., demonstrates the carbon footprint for the entire lifetime of several modes of transport, refer to Figure 5. Values range from their optimum to their worst-case use [49]. This study also shows that private internal combustion engine (ICE) vehicles have the largest environmental impacts, having a carbon footprint ranging between 200-270 $gCO_2eq/(pax*km)$. Other private vehicles such as ICE mopeds, hybrid and electric cars range between 80-180 $gCO_2eq/(pax*km)$, 60-160 $gCO_2eq/(pax*km)$ and 80-150 $gCO_2eq/(pax*km)$, respectively.

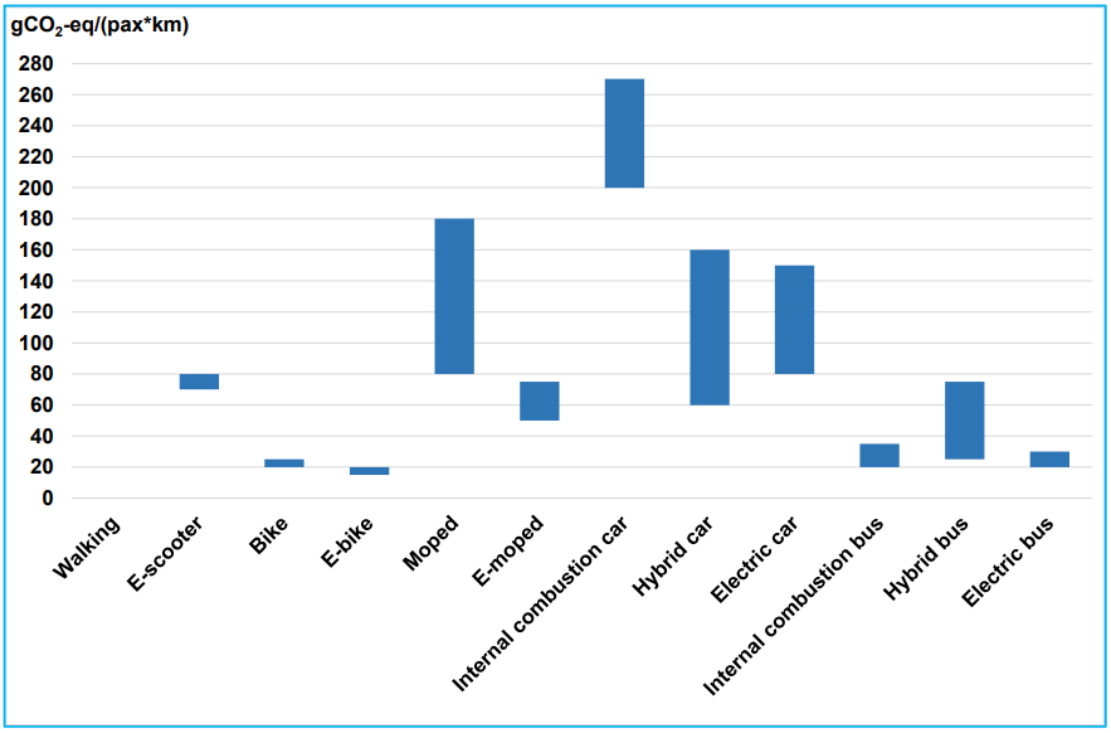

Figure 5 - Range values for unit emission factors in the case of the entire life cycle [49]

As can be seen, all micro-modes of transport (e-scooter, e-bike and bicycle) have a lower carbon footprint than that of an ICE private car, hence being more sustainable than the prevailing use of ICE cars. Results show that bikes have a carbon footprint ranging between 20-25 $gCO_2eq/(pax*km)$, and e-bikes having the lowest range between 16-20 $gCO_2eq/(pax*km)$ [49].

As can be seen in Figure 5, bikes and e-bikes not only display better results to private cars and e-scooters, but they can also be rather competitive, in terms of their carbon footprint, to ICE, hybrid and electric buses, which collectively have a minimum carbon footprint of around 20-25 $gCO_2eq/(pax*km)$ [49]. This tallies with the case study of China mentioned earlier in this section, that show that bicycles have the lowest carbon footprint in comparison to the private car, buses and subways [48]. It should be noted that buses have a significant larger carrying capacity which is the primary reason as to why they are displaying lower environmental impacts than private cars and mopeds [49].

Furthermore, D'Acierno et al. demonstrates the ratio of mass to service life (in years), per person (I'_m), of same modes of transport. Refer to Figure 6 [49].

Transport Mode	Mass [kg]	Service Life [years]	I_m [kg/year]	I'_m [kg/year*pax]
E-scooter	16	2	8	8
Bike	15	15	1	1
E-bike	25	5	5	5
Moped	150	6	25	22.73
E-moped	150	6	25	22.73
Internal combustion car	900	15	60	46.15
Hybrid car	900	15	60	46.15
Electric car	900	10	90	69.23
Internal combustion bus	15,000	15	1000	12.5
Hybrid bus	15,000	15	1000	12.5
Electric bus	15,000	10	1500	18.75

Figure 6 - Table showing a comparison of different transport modes in terms of mass and service life [49].

As can be seen, highlighted in green, in Figure 6, micro-mobility modes of transport display the best values, with the bike being the preferred. ICE, hybrid and electric buses follow, as mentioned before due to their significant large carrying capacity. On the other hand, mopeds display worse values, while private cars display the worst values, highlighted in red in Figure 6, with the electric car resulting in the worst, particularly due to its lower service life of 10 years [49].

E-scooter

As can be seen in Figure 5, e-scooters have a carbon footprint ranging between 70-80 $gCO_2eq/(pax*km)$, which is lower than that of ICE private cars [49]. On the other hand, according to a case study in Portugal, by Reis et al., an e-scooter emits around 804 to 1679 gCO_2eq/km (per person). This higher value can be due to the e-scooter's lower use rates and reduced life span. As can be observed, the ranges are quite wide, and as Reis et al. explained, the primary reason of this is because of the large variability as to how e-scooters are used; as per their worst-case or optimum case. This is dependent on the user, the length of trip, the route taken, the quality of road infrastructure (whether they have any potholes or bumps), hilliness as well as it is dependent on the battery charging and use patterns. According to Reis et al. increasing the e-scooter's life expectancy reduces environmental impacts by around 26% up to 47% [2].

The fact that Figure 5 shows that e-scooters is the most polluting micro-mode of transport, tallies with Calan et al. who also claimed that e-scooters sharing services appear to be the most polluting micro-mobility mode. Calan et al. obtained a carbon footprint ranging between 55 to 213 $gCO_2eq./pkm$, noting a larger variability in the results, in comparison to Figure 5 [31] [49]. Interestingly, Calan et al. made the comparison of the e-scooters' carbon footprint for those having a lifetime of more or less than a year. Considering a lifespan of more than 12 months, a GPW ranging between 55 and 109 $gCO_2eq./pkm$ was obtained, while lifespans being less than 12 months, obtained a Global Warming Potential (GWP) ranging between 126 to 213 $gCO_2eq./pkm$ [31], confirming that the scooters with a longer lifetime have a reduced impact on the environment.

Referring back to Figure 5, the minimum carbon footprint values for ICE mopeds, hybrid and electric cars range close to the carbon footprint of e-scooters, with e-mopeds, which have a carbon footprint ranging between 50-75 $gCO_2eq/(pax*km)$, displaying an even lower carbon footprint than that of e-scooters. This suggests that e-scooters can have a greater impact to the environment than these modes of transport, especially when misused, highlighting the importance of optimising the quality, robustness and operation of e-scooters [49]. Calan et al. also showed that e-mopeds have a carbon footprint ranging from 34 to 79 $gCO_2eq./pkm$, which tallies with the range in Figure 5 [31] [49]. Moreover, Calan et al. did point out that sometimes the average occupancy of e-mopeds exceeds one passenger per vehicle [31].

Comparing to the study by Calan et al., the too short-lifespan of e-scooters results in higher carbon footprint values than the subway (also known as metro) and walking, deeming e-scooters as less sustainable [31]. Moreover, according to D'Acierno et al., shared e-scooters pollute more than an electric bicycle, an electric motorcycle, and can even have greater impacts than an electric car. As seen in Figure 5, the minimum carbon footprint of an electric car and the maximum carbon footprint of an e-scooter, coincides at 80 $gCO_2eq./pkm$ [49]. This tallies with what Kubik said, who compared the energy use between e-scooters and electric cars. The results generated by Kubik's study show that the electricity requirements for six scooters only corresponded to one electric car, which is not so significant. This raises the question of whether e-scooters are the best form of electric mobility for the environment [50].

Referring back to Figure 6, the reduced mass to produce e-scooters allows them to be more sustainable than mopeds, cars and buses, however, the shorter life expectancy of two years for e-scooters, as well as the 5-year life expectancy for e-bikes, should not go unnoticed, begging the question as to why the service life is so short for these electric micro-modes of transport [46].

As found in a study by Bozzi et al., shared e-scooters generally pollute more than the transport modes they tend to replace, particularly buses, cycling, and walking. This is primarily due to their unsustainable manufacturing processes, the shared companies' profit centred business models, the use of petrol-based vehicles for rebalancing and the short lifespan of the vehicles [44]. Cafiso et al. claimed that the shorter lifespan for e-scooters is primarily due to the quality of pavements (including unevenness, cracks, potholes) which may additionally make riding uncomfortable or hazardous, especially with smaller wheels and components that are susceptible to wear and tear [51].

Calan et al. went on to say that e-scooters have the potential to reduce the GHG emissions in Paris if they are substituting trips that would have been made using less environmentally friendly modes, including private cars, taxis, and ride hailing services [31]. Although they are the most polluting micro-mobility mode, e-scooters are the mode that has been studied the most in literature [31]. Finally, the findings by Kubik suggest that new micro mobility services may not always be the best environmental solution for urban mobility. This is true unless a more holistic understanding is obtained, including the life cycle stages of the product. Unless the eco-design and energy efficiency of vehicles is improved, their energy source is from green renewable resources of energy, and micro mobility services are strategically used and deployed as part of a holistic vision for transport, micro mobility services may continue to cause more harm than good [52].

2.2.4. The Life Cycle Phases of Shared Micro-Mobility Services

The life cycle of a product poses several sustainability impacts. The life cycle takes into consideration the different phases of the life of a product, particularly the production phase, the distribution phase, the use phase, maintenance and operations phase as well as it's end of life phase [53]. Impacts on the environment, resource and materials use and energy use are discussed further below.

Reis et al. determined the energy percentage use of e-scooters throughout the different stages of its life cycle. 70% of the total energy use during the products' life cycle is attributed to the early production and manufacturing phases of e-scooters, while 17% only is attributed to the vehicle use phase. 6% of the energy use is attributed to collection and distribution processes [2]. The high energy percentage during the manufacturing phase suggests that e-scooters make use of heavy industries, however in comparison to a private car, that is not the case as discussed further below. This, together with the significantly lower energy use percentage during the use phase, suggests that e-scooters have a short lifetime than expected [2]. This is discussed further below.

The following section discusses the impact on sustainability on all shared micro-mobility modes of transport. This is done by analysing their life cycle phases, particularly the manufacturing phase, their use phase and their operations and maintenance phase. By analysing literature and studies conducted by previous authors, a holistic image on the different phases of micro-mobility modes of transport is understood.

Materials Used and Manufacturing Phase

Shared micro-mobility is a solution to single-occupancy vehicles (SOV), where vehicles are only driven by one person and the other seats are left vacant [10]. Primarily, this is because shared micro-mobility modes of transport including scooters and bikes are physically smaller than cars and motorcycles, having a lower carbon footprint and utilizing less energy as shown further in this literature review. Micro-modes of transport are an ideal solution for those SOVs on the roads as commuters take up less space and reduce traffic congestion.

In turn, shared micro-mobility of transport require less resources and raw materials to produce them, in comparison to private cars. E-scooters weigh between 15kg and 35kg [44] [49] while e-bikes range between 15kg and 51kg [31] [49]. The sharing concept results in the fact that the same individual asset can be used by several users at different times, for various trips, rather than each user owning their individual asset [25]. This reduces the overall number of assets required to perform all these trips, as the same vehicle is shared amongst the users [9]. Moreover, although being physically smaller, micro-modes of transport are also less complex to produce. There are less parts and less raw materials in bicycles, e-bikes and e-scooters, when compared to a private car. The

manufacturing of these vehicles is simpler and does not require parts and processes obtained through energy intensive heavy industries [2]. This means that shared micro-mobility services reduce resource depletion and reduce the energy demand during their manufacturing phase [2].

According to Calan et al., the most impactful materials on e-scooters are the Aluminium (Al) body and the lithium-ion batteries. These two materials emit up to 73% of the total emissions during the manufacturing processes of e-scooters [31]. Al makes up more than half of the mass of the e-scooter and has the highest environmental impact during the manufacturing phase of e-scooters. On the other hand, the lithium batteries are considered the second most polluting material in e-scooters [31]. In fact, a study by D'Acierno et al. shows that the manufacturing emissions of bikes amount to around 5gCO_2-eq/km, while those of an e-bike amount to 7gCO_2-eq/km, the primarily difference being the battery involved [49]. However, according to Calan et al., it is the significant use of Al alloys which results in the manufacturing phase standing out as the most significant contributor towards pollution during an e-scooters lifetime [31].

In fact, as mentioned before, Reis et al shows that the manufacturing phase for e-scooters amounts to around 70% of the total environmental impacts during the e-scooters' lifetime [2]. In comparison, the materials and manufacturing phase account for 41% of the total Global Warming Potential (GWP) for e-moped sharing services, and 48% for e-bikes, which are both less than that of e-scooters [31].

Use Phase

Shared micro-mobility services require less parking space, not only because of their physically smaller size, but because unlike private vehicles, which are parked 95% of the time, shared micro-mobility services are constantly being used [10]. As mentioned before, the sharing concept allows more than one user to use the vehicle at different times. Hence, the time spent parked and the parking space required is significantly reduced [25]. They also require less space on roads and hence, reduce traffic congestion and wasted space as there are less cars and SOVs on the roads. Additionally to their smaller size, they are able to by-pass traffic and use promenades, pavements, parks and pathways rather than tarmacked roads [3] [25]. The reduced demand for parking spaces and space on the roads, reduces the need and costs for big infrastructural roads and projects [3]. This reduces the overtaking of agriculture and natural land for these

projects, retaining ecosystems, habitats and safeguarding the natural landscape and systems - such as the underground water table [3].

The reduced traffic congestion also benefits society [9]. Moreover, to the user, the sharing concept is also beneficial because rather than purchasing and owning a vehicle, including the space to store the vehicle when not in use, the costs to own and sustain a vehicle, including their operation and maintenance, is managed by a service. Hence, all of these costs are shared amongst several users who are making use of this service [3].

For a shared micro-mobility business, the target is to reach out to as many commuters as possible and have their assets constantly being used. Hence, the less time a bike or e-scooter spends parked, the more revenue it generates, as that means their assets are being used more regularly on the roads. This reduces the number of assets a service provider needs to purchase, operate and monitor [25] [46].

Micro-modes of transport require significantly cheaper infrastructure than that of private cars. Not only can micro-modes of transport utilise infrastructure used by pedestrians (pavements, promenades and parks), in addition they only require cycling lanes, segregated lanes, pathways and parking spaces [25] [43]. According to Shaheen et al., the introduction of BSS in Paris has resulted in an increase in cycling infrastructure, enhancing a more cycling-friendly culture. In fact, in their study it was determined that following the launch of BSS in Paris, cycling increased by 70% [24].

Moreover, the perception of cycling has changed, as it is no longer just associated as something for poor people, or only as a sport or leisure activity, but as a regular mode of transport. Through their survey, Maas et al. determined the top three motivating factors for shared micro-mobility services consistent among the three cities, including Limassol, Las Palmas de Gran Canaria and Malta [41]. Respondents described shared micro-mobility services as “healthy”, “environmentally friendly” and “fun”. The overall satisfaction with the BSS in all three case study cities was considered as high [41].

However, according to Félix et al., common barriers to the use of BSS include the lack of safe cycling infrastructure and cycling lanes or networks, road safety and busy roads. Other barriers such as too long distances, elevation and hilliness also discourage BSS and scooter use [27] [38].

Operations and Maintenance Phase

Rebalancing of shared micro-mobility vehicles is a crucial day-to-day activity to sustain the service and outreach of users. Services make use of vans or other forms of vehicles to collect their assets, with service distances ranging from 0.02km to 2.5km, and having a GWP ranging from 5.5 to 54 gCO_2eq/pkm [31]. In Brussels, rebalancing of e-scooters is the phase with the second biggest impact and is responsible for around 20% of Greenhouse Gas (GHG) emissions [54].

The use of a station-based bike service requires less rebalancing in comparison to dockless systems [55]. In fact, an investigation carried out in Barcelona shows that station-based e-bike services demonstrate lower emissions, even when considering for the inventory of the docks and station infrastructure [31]. The station-based system emitted around 65 and 68 $gCO_2eq./pkm$ while the dockless system emitted around 118 and 130 $gCO_2eq./pkm$ [31].

The study by Reis et al., discussed earlier, shows that maintenance accounts to around 16% of the total GWP in the lifetime of an e-scooter. Maintenance efforts result due to misuse, rough pavements or steep slopes. In fact, each e-scooter was maintained an average of 2.76 times a month while the battery was changed 0.68 times a month [2].

The use phase of shared micro-mobility assets can result in misuse, theft and vandalism. A shared e-scooter's lifetime mileage ranges to around 4000km. In comparison to a shared e-bike, the rate of replacement is 20% while the lifetime mileage ranges between 5,500km and 13,200km, which is more than that of an e-scooter [31].

A study by the German Energy Agency, shows that first-generation e-scooters, with permanently installed batteries, have a greater environmental impact than second-generation e-scooters with swappable batteries [56]. This is because those that have swappable batteries tend to have a longer lifespan. This tallies with Kazmaier et al., who claimed that e-scooters with swappable batteries decrease the GWP by 12% [57].

Services are now pushing to only use fuel-efficient vehicles (e-vans) for collection of assets. Not only are services opting to employ and enforce the use of solar energy to charge their batteries, they are also limiting the replacing of batteries to those assets having a significant low battery charge. In fact, swapping batteries every six days instead of two days can reduce emissions by a third [58] and less frequent collection of e-scooters would improve environmental impact results by around 42% [2]. Together with

making use of e-vans and solar energy, the environmental impact can be reduced by more than 50% [58]. This tallies with a study in Brussels which shows that these new trends might reduce rebalancing emissions by over 30% [54].

Table 1 below was created to summarise the sustainability aspects of the micro-mobility modes of transport and to make a comparison to the private ICE and EV cars, as discussed in this literature review in Sections 2.2.3 and 2.2.4.

	E-scooter	Bicycle	E-bike	ICE Private Car	EV Private Car
Carrying Capacity [49]	1	1	1	5	5
Average Lifespan (in years) [31] [49] [59]	1-2	15	5	15-30	10
Lifetime mileage (in km) [31] [59] [60]	4,000	unknown	5,500-13,200	320,000 – 1,600,000	160,000-320,000
Mass (in kg) [31] [49]	15-35	15	15-51	900	900
Energy % during Manufacturing phase [31] [61]	70%	<48% (or 5gCO_2-eq/km)	48% (or 7gCO_2-eq/km)	7-22%	
Carbon Footprint Ranges (in gCO_2eq/(pax*km)) [49]	70-80	20-25	16-20	200-207	80-150
Energy Source	Electric*	Human Physical Effort	Electric*	Fossil Fuel	Electric*

Table 1 - Summary comparing the sustainability aspects of micro-modes of transport and the private car.

*Electric sources have the potential to be generated through green renewable sources of energy, but this depends on the current energy mix and choices made by operators.

2.2.5. Requirements of Shared Micro-Mobility Services

Several studies and authors have discussed the necessary requirements for share micro-mobility services. Through their studies, remarks and results, gathering the necessary requirements for shared micro-mobility, are discussed in this section of the literature review.

Primarily, shared micro-mobility services need to have a competitive advantage over other means of transport particularly, the dominating mode of transport - the private car. In fact, a study by Camilleri et al. conducted semi-structured interviews of the individual experiences of commuting, and suggestions for more sustainable transport were gathered. These include car disincentives such as, reduced car advertising and sales and car free days, making the car the least likely choice for travel [62].

Maas et al. explained that one of the most important necessary requirements to obtain a competitive advantage is to extend the road space allocated for shared mobility modes through a series of shared priority lanes and a safe cycling network, especially for "starter" cycling cities, such as Malta. Camilleri et al.'s interviews tally with this requirement [6] [41] [62]. Likewise, Maas et al. said that the creation of dedicated cycling paths as part of a connected cycling network between residential, employment and entertainment areas could further promote cycling and BSS use [38]. Segregated lanes and cycling networks provide a safe route while also provides a competitive advantage over private cars as such lanes allow active commuters to by-pass traffic. The provision of bridges, elevators or a special bicycle lift (such as, the Trampe bicycle lift in Trondheim, Norway) will continue to enhance the cycling network [38]. This tallies with what Chardon et al. determined, stating that the provision of safe infrastructure is one of the main determinants for more cycling and BSS use [63].

Notably, e-scooters do not require any physical effort to operate, while bikes need to be pedalled. This may have been proven to be a significant entry barrier for some users [64], however, training programmes for active modes of transport may be provided, as recommended by the results of Camilleri et al.'s interviews [62]. To overcome elevation challenges, several strategies can be pursued. The provision of electric bicycles, although more expensive for the operators, can play a role in encouraging uptake among new target groups and for trips to destinations located at higher altitudes and longer distances [38].

Another competitive advantage of shared mobility are lower costs and reserved parking which can be other encouraging factors for the use of shared services. Parking stations is a necessary requirement for shared micro-mobility services and to increase the coverage and connectivity of such services, the density of stations can be increased by creating more, small-sized, stations, particularly in areas with many points-of-interest (POI) [65]. Providing ancillary facilities such as showers and lockers at key destinations can also aid in mitigating the effect of exertion or high temperatures as a barrier to cycling [38].

According to Bajada et al., changing people's mind set on shared micro-mobility in Malta remains a long process [66]. However, a positive social norm towards active commuting and cycling, is needed so as not to discourage but to encourage the use of cycling. Mass media campaigns, promotion of health, motivational programs and community events can help in changing such social norms and culture [6] [62]. Additionally, marketing may be necessary to explain and communicate the true costs of owning and driving a private car versus a shared car, especially at key moments when people decide to purchase a car. Future campaigns or marketing should target the 18-24 age category, before the formation of the private car use habit [6].

In fact, results from a survey conducted amongst 1,100 Maltese residents by Maas et al., in 2022, showed that there is a strong positive relationship between the younger ages, having higher education levels and being full-time employees, and the acceptance of bicycle and car sharing concepts [47]. However, there is still a large share of respondents who are not yet aware or able to accept these new shared mobility services. Maas et al. went on to say that more information about the advantages, including monetary and time savings, needs to be shared and understood. Maas et al. also concluded that to further promote the use of shared micro-mobility services, improved road safety, safe cycling infrastructure and safe cycling routes are essential, which tallies with previous remarks made earlier [47].

Maas et al. spoke about the importance of road safety and cycling safety awareness. Awareness of active transport and the use of e-scooters and bicycles is required amongst all road users including drivers of cars, buses and trucks, as well as pedestrians. All need to be aware of the rules and expectations of these modes of transport [6]. The reduction

of speed limits on residential and rural roads by cars, buses and trucks, provides a safer road for active commuters.

Integration of shared micro-mobility services to the current methods of commuting and transport modes, the current electric grid and methods of charging, and the infrastructure at hand, is another key requirement for shared micro-mobility services. The easier it is for such services to be able to integrate with the current state, the more successful such services become. Zhi et al. went on to explain that integrating these modes of transport into a single platform to provide user-customized travel planning, booking, payment and information inquiry through a mobile application, helps shift persons' mobility behaviours and reduce private car use [48].

A study, by Bajada et al., conducted semi-structured interviews with seven local councils in Malta. One local council highlighted the importance integrating active modes of transport with the public transport service in Malta, highlighting that public transport does not work properly and people are reverting to using their personal cars. Other integration measures implemented by local councils include bike storage and signage to encourage the use of bicycles [66].

2.3. Summary

Shared micro-mobility services, such as bicycle, e-bike and e-scooter services, provide several sustainability benefits, such as reduce the number of vehicles on roads, reduce traffic congestion and reduce the need for parking spaces [3] [25]. They offer an alternative to commuting, promoting healthy active mobility, and the use of alternative routes, such as promenades and parks [24] [25]. They are significantly cheaper than owning a private vehicle, and a reasonable alternative for young commuters [6]. They have the potential to reduce environmental impacts, such as the carbon footprint and GHG emissions [49]. Although a shorter lifespan than a private vehicle, their reduced impact on resource depletion poses significant benefits, reducing the overall environmental impacts [31] [49] [59]. Second generation shared micro-modes of transport are looking towards the future to enhance their optimum case use amongst users, increase energy efficiency and reduce energy impacts, and increase their sustainability advantages.

A competitive advantage and a positive social norm towards active commuting is needed so as not to discourage the use of shared micro-mobility services [62]. Road safety and awareness is crucial for all road users to have [6]. Integration of these modes of transport to current infrastructure and systems, as well as other facilities, are crucial for a smooth implementation of shared micro-mobility services to the current transport scenario [48].

Chapter 3: Research Methodology

This chapter explains the research methodology for this study. This chapter explains the work that was conducted throughout this study and provides an explanation as to how results were obtained.

3.1. Research Design

The case of shared micro-mobility services in Malta was considered for this dissertation. Case studies offer in-depth information and specific findings about a particular case. Although providing detailed information about a single example, it provides clear details of a complex scenario. Most importantly, case studies can be transferrable to other cases having similar contexts [67].

Malta is an archipelago of only 316 km^2 and has a population of more than 560,000 people. 25% of the population are foreign immigrants, while Malta receives significant number of tourists, in 2024 there were 3.5 million tourists [68] [69] [70]. The Gross Domestic Product (GDP) per capita of Malta is €39,500 (which is well above the EU average). Malta contributes to 0.1% of the EU's total GDP [70]. The island

has a car-oriented society, and although small, it may offer lessons for other cities that share the same level of economy and quality of life, in relation to shared micro-mobility services [68] [67].

Malta lies in the middle of the Mediterranean Sea, just 90 km south of Sicily, and has a typical Mediterranean type of climate, with mild winters and warms summers. Malta is characterised with higher land towards the west and a low-lying eastern side. Most settlements in Malta started as nucleated settlements, with narrow, winding roads radiating from a village core. Urban sprawl led to individual towns overlapping each other, and few settlements in Malta show physical boundaries. This led to a densely populated region, surrounding the capital city Valletta, where other prominent towns flank the eastern coast of the island [68] [67].

The urbanisation led to most of the industrial and commercial activities taking place within the Eastern coast of Malta, while Valletta became the main administration hub of Malta. Malta has an extensive road network, one of the densest worldwide. Like settlements, roads radiated out from village nuclei. The road network is comprised of

arterial roads linking the North and South of Malta, linking towns and villages in the process, followed by secondary roads for more local access roads [68].

Commutes in Malta are characterised by personal vehicles or public transport. Maltese have a culture of owning cars, even amongst adolescents. Poor land use and planning, and high car ownership led to traffic congestion being regular, especially during rush-hours, leading to parking problems, road rage and bad air quality in settlements due to the air pollution from fossil fuel vehicles [68] [67].

Shared micro-mobility services were an alternative of commuting, gaining popularity in recent years, like any other European city. However, shared e-scooter services were abruptly banned in Malta, and other shared e-bike services left the islands, leaving very little alternatives to commuting, other than the private car or public transport [19] [20].

At present, an active plan; published towards the end of March 2025 (after the completion of the semi-structured interviews – which were conducted from January 2025 to February 2025); called *Reshaping Our Mobility* has been developed by the Ministry of Transport, which involved a number of measures to encourage other modes of transport other than the private car. Most striking, the government is providing a €25,000 incentive for Maltese car drivers to give up their license for five years. The government is also promoting the use of mopeds, providing a €1,500 a year incentive and considering allowing 17-year-olds to drive mopeds. A motorcycle cash grant between €750 and €1,000 is also being reintroduced. The government is also adding new bus routes, park-and-ride services, as well as increasing the frequency and extending the routes of current public transport services [71] [72].

In terms of micro-mobility, the Maltese government is providing a €150 incentive for Maltese applicants to purchase their own e-scooter, as well as a once-only grant of 15.25% on the purchase expense of their bicycle, up to a maximum of €85 for a bicycle and up to €250 for a pedelecs (electric bicycles or e-bikes) [73] [72] [74]. In terms on infrastructure, the government has started works in November 2024 on a €35m cycle network [75].

Although the incentives to purchase e-scooters and e-bikes, the improved public transport, park-and-ride and ferry services, improved bus routes, and the implementation of a cycling network and lanes, are all beneficial to offer commuters the option for active mobility, the sharing services are still not being mentioned. From the government's

recent stance, it seems that there is no push to reintroduce shared micro-mobility services back in Malta, while the only push for these modes of transport is for privatised use. This is the reason why this research surrounds Malta's case, to try and understand whether there is a place for shared micro-mobility services in Malta, in the near future.

3.2. Research Questions and Objectives

Following a thorough literature review and formulation of the aim; To perform a sustainability assessment on shared micro-mobility services in Malta, to truly understand their sustainability advantage, to understand the reasons why they stopped operating in recent years, and to make recommendations for their inclusion in sustainable transport locally, the research questions and objectives were formulated for this study.

3.2.1. Research Questions

The research questions were formulated to reflect the aim: To perform a sustainability assessment on shared micro-mobility services in Malta, to truly understand their sustainability advantage, and understand the reason for such mobility services to stop operating in Malta in recent years. The research questions were articulated as follows:

1. To what extent are shared micro-mobility services sustainable?
2. What are the conditions that are required to sustain a shared micro-mobility service?
3. What are the determinants that led to these shared micro-mobility services leaving the islands?
4. What is the current local position of transport policy regarding shared micro-mobility?
5. What are the recommendations from transport stakeholders for future transport policy to promote shared micro-mobility?

3.2.2. Objectives

This section provides the link between the research questions and the objectives. The objectives provide the rationale that led to the research questions.

- Objective 1:

  To determine the sustainability advantage and conditions required to maintain a shared micro-mobility service in Malta

This objective aims to answer Research Question #1 and Research Question #2 – from literature, shared micro-mobility services offer sustainability benefits [3] [25]. However, it seems this was not the case in Malta, leading to the ban of shared e-scooters, and reduced shared mobility alternatives across the islands [19] [20]. This objective aims to understand the true sustainability benefits and impact of shared micro-mobility services, while also aims to understand those requirements that are necessary to sustain such a service and make it sustainable. To do this, semi-structured interviews and a sustainability assessment (as explained in sections 3.3.1 and 3.3.2) will be conducted.

- Objective 2:
  To determine what led to the departure and/or halting of shared services:

This objective aims to answer Research Question #3 – from literature, shared micro-mobility services were introduced in 2016 and 2018, but in 2024 a ban was put in place for shared e-scooter services, and other shared services, including Nextbike shared bicycles, left the islands [19] [20]. To do this, the semi-structured interviews (as explained in section 3.3.1) should determine those reasons for their departure or halting of service.

- Objective 3:
  To determine the current and future positions of shared micro-modes of transport within transport policy:

This objective aims to answer Research Question #4 and Research Question #5 – the current and future positions government and policy makers are taking, in view of micro-mobility, is of significant interest. Reviewing current policies (through a policy review as explained in section 3.3.3) should determine what measures and enforcement were in place, and together with the interviews, an understanding of what gaps were present, will be determined. Most interestingly, recommendations from the interviews and a look to the future will determine what the future holds for shared micro-mobility services in Malta.

3.3. Research Methods

The type of data that was gathered as part of this study is qualitative, obtained from the semi-structured interviews, a simplified sustainability assessment and a policy review, as explained further in Sections 3.3.1., 3.3.2. and 3.3.3., respectively. Through the semi-structured interviews and the simplified sustainability assessment a holistic understanding of the perception of shared micro-mobility services in Malta was obtained, including the requirements as to what was needed to ensure the success of shared micro-mobility services (in Malta) and the reasons for their departure or halting of service. Through the policy review, an understanding of the current and future positions of shared micro-modes of transport was determined. This understanding was heightened through the semi-structured interviews, were participants provided recommendations for the successful implementation of such services and active transport in Malta.

3.3.1. Semi-structured Interviews

Specific knowledge was acquired from the semi-structured interviews. A purposeful sample method was used in order to select the persons participating in the interviews. The participants were selected based on having adequate knowledge, experience, involvement and a particular interest in shared micro-mobility services, as well as sustainable transport in Malta, in general. Participants included representatives of offices in government and public entities, non-governmental organisations (NGOs), service providers of shared micro-mobility and other users of shared micro-mobility. Participants were all over the age of 18. Interviews were conducted from January 2025 to February 2025.

A total of 18 participants accepted the invitation to participate in the interviews for this project. As shown in Table 2, half of the participants held a position in government or public entities, whereas the rest were a combination of representatives from NGOs, service providers and users.

Participants' Description	Number of Participants
Representatives of Offices in Government and Public Entities	9
Non-governmental organisations (NGOs)	5
Service Providers	2
Others	2
Total:	**18**

Table 2 - Number of participants who participated in this project.

The type of interviews that were conducted are semi-structured. This type of interview method makes use of questions that are predetermined. These are then complemented with prompts, such as “can you elaborate…”, “how would you respond to…” or “what is your view on…”. This type of interview required open-ended questions, allowing participants to expand on their responses, give examples and personal opinions.

A total of four predetermined questions were asked during the semi-structured interviews. The choice of questions was derived from the research questions of the study. The four predetermined questions were as follows:

1. What is [stakeholder’s] view on the promotion of shared micro-mobility services as a more sustainable mode of transport, in comparison to privatised combustion engine vehicles or public transport. How does [stakeholder] perceive shared micro-mobility services in Malta?
2. In your experience and expertise, what are the necessary requirements for the successful implementation and operation of shared micro-mobility services, particularly in Malta?
3. What were those attributes that led to shared micro-mobility leaving the island?
4. Can you elaborate on what you foresee as the successful implementation of shared micro-mobility services in the upcoming years in Malta?
    a. What recommendations can you provide for the future successful implementation of shared micro-modes of transport?
    b. Or what alternative recommendations can you provide for future sustainable transport?

Invitations to participate in these interviews were sent to each stakeholder via email. The interviews took place online and lasted a maximum of 30 minutes. These interviews were voice recorded with the purpose of transcription for the author’s use only. The participants remained anonymous throughout the study. The necessary research and data protection form (UREC form ENG-2024-00139) was processed prior to the interviews, and an information sheet and consent form were provided to the participants before the interviews. The consent form was signed by every participant and every participant had the option to stop the interview any time they wished. All data gathered, including voice recordings shall be deleted following the submission of the dissertation and published result.

Once the interviews were transcribed, a content analysis of the data was carried out. A content analysis examines qualitative or quantitative data and frequencies of data content are identified. This included a quantitative approach were the presence, reoccurrence or frequency of keywords, themes or concepts, at a surface-level, from qualitative data, are determined [76]. The content analysis included the use of frequency charts to visually represent the participants' responses. Quotes from the interviews were used in the analysis to supplement arguments and give examples, as appropriate.

Through these semi-structured interviews, several reasons were gathered as to why such services of shared micro-mobility modes of transport left the Maltese Islands. Moreover, an understanding of the business opportunities, local culture and way of thinking, the disincentives Malta presents for these modes of transport (including the quality of road or network infrastructure) and the technical capability were obtained. Expert-based recommendations for sustainable transport was also obtained.

3.3.2. Sustainability Assessment

A simplified sustainability assessment was performed on the use of shared micro-mobility modes of transport in Malta. The sustainability assessment was conducted through a thematic analysis of the responses of the structured interviews. A thematic analysis is an intuitive approach to qualitative data analysis which allows researchers to explore patterns or key themes across their data [76]. The thematic analysis revolved around themes and remarks on the three pillars of sustainability and on the life cycle assessment (LCA) of shared micro-modes of transport.

The three pillars of sustainability are principles which are standard, used for assessing the impact and sustainability of a product. These are divided into three main areas; environmental, social and economic criterion, where the first analyses the ecological impact, the second considers working conditions, human right and people, while the latter evaluates business needs, ethics and management [77]. On the other hand, an LCA is the process of evaluating the effects on sustainability of a product over the entire period of its life. LCA is commonly referred to as a "cradle-to-grave" analysis [53].

Themes on the three pillars of sustainability and the life cycle of shared micro-mobility services were obtained from the transcriptions of the semi-structured interviews. The simplified sustainability assessment provided a holistic understanding of the overall

benefits and drawbacks of shared micro-mobility services, particularly on the energy use and resource consumption, throughout their entire lifecycle.

3.3.3. Policy Review

A policy review exercise was conducted on two national documents which are complementary and attributed to sustainable transport in Malta. One is the strategy document, the National Transport Strategy 2050, and the other is the masterplan, the National Transport Master Plan 2025. The former is a vision outlining where Malta's transport sector wants to be in the long run, providing strategic goals and direction on how to get there, while the latter sets out the framework and priorities guiding the transport sector over a short to medium term.

The policy review was performed to understand the importance shared micro-mobility is being given within these documents and the vision, way forward and implementation to try solving national problems related to transport and achieving more sustainable Transport management in Malta. This review was done through a content analysis, where keywords such as "shared" or "sharing", "scooter/s", "bicycle/s", "e-scooter" and "e-bike", were searched in both documents. The frequency of their appearances was quantified and presented accordingly.

Chapter 4: Results and Analysis

This chapter presents the results and their analysis for this study. Firstly, results from the semi-structured interviews are presented. Through a content analysis, results are presented in charts, displaying the participants' responses of the four interview questions asked during the interview. Moreover, the content analysis is supported by quotations from the interviewees.

Secondly, a simplified sustainability assessment is generated based on the advantages and disadvantages, gathered throughout the semi-structured interviews, on the three pillars of sustainability of shared micro-modes of transport. Thirdly, results from the policy review of the national transport policy documents are presented.

4.1 Semi-structured Interviews and Analysis

The first question asked was *"What is [stakeholder's] view on the promotion of shared micro-mobility services as a more sustainable mode of transport, in comparison to privatised combustion engine vehicles or public transport. How does [stakeholder] perceive shared micro-mobility services in Malta?"* Primarily, this question aims to understand the perception and position the representative of an organisation or participant has towards shared micro-mobility, whether they are in favour of or against such services in Malta. This will give an understanding as to whether they will promote or discourage such services in the near future. Additionally, this question will help answer Research Question #1 and determine how truly sustainable shared micro-mobility services are, particularly in Malta. Results of the first question are shown in Figure 7:

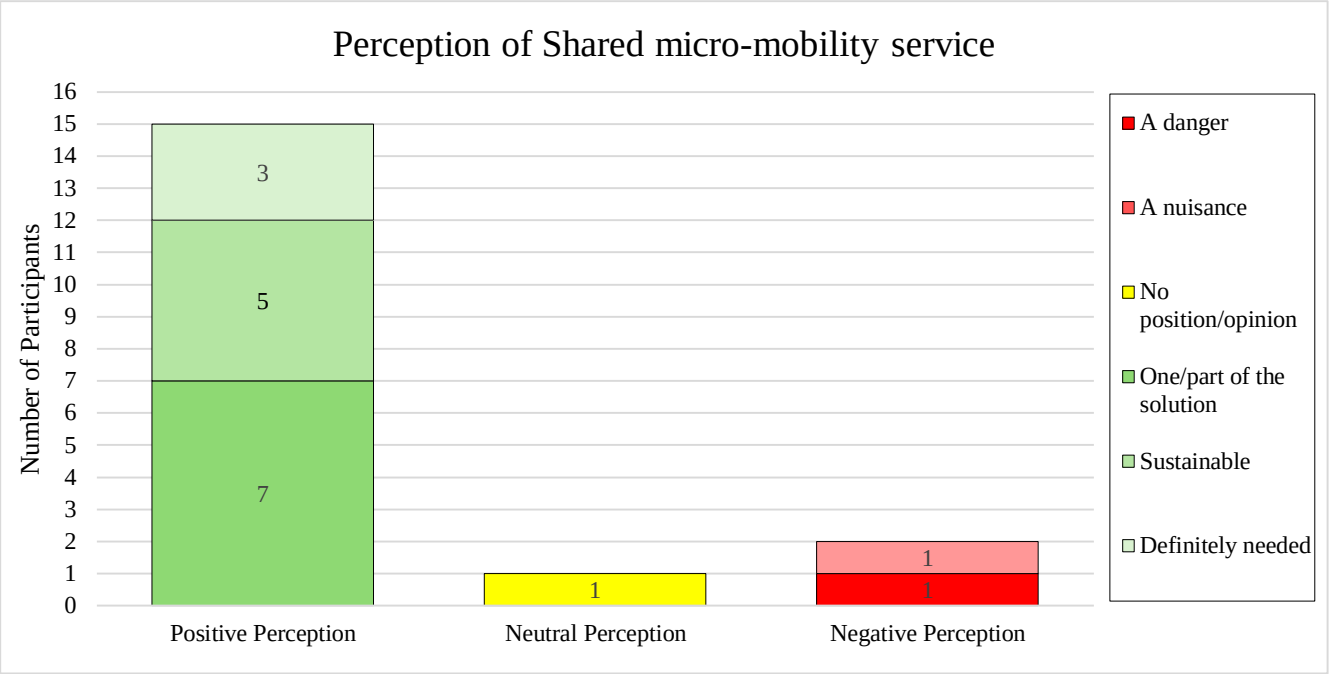

Figure 7 - Bar chart showing the perception of shared micro-mobility services amongst participants.

As can be seen, 15 out of 18 respondents had a positive perception towards shared micro-mobility services in Malta, with seven of them responding that shared micro-mobility should be considered as part of the solution. When asked to elaborate, participants responded that shared micro-mobility should not be introduced or implemented as a service in isolation but should be appropriately integrated within the current modes of transport currently present in the islands, particularly public transport. Meanwhile five of the respondents responded that they perceive them as sustainable. The reasons participants gave as to why shared micro-mobility modes of transport are perceived as having a sustainable advantage are demonstrated in a more in-depth sustainability analysis in Section 4.2. These are split according to the three pillars of sustainability – environmental, economic and social pillars, and the analysis consolidates all feedback on their sustainability, obtained throughout the whole interview. Finally, three of these participants having a positive perception toward shared micro-mobility responded that such modes of transport are definitely needed to solve our transport problems. It should be noted that these three respondents were representatives of NGOs.

As per Figure 7, one out of 18 respondents did not perceive them as positive nor negative, while two out of 18 respondents had a negative perception towards shared micro-mobility, with one describing them as a nuisance and another as a danger. Participants claimed that “people were finding a scooter in front of their house, every

day, they obviously got upset". Others claimed that e-scooters are being used in a "dangerous manner", speeding and swerving through traffic or speeding on pavements or even "sometimes you see two people standing on one scooter which is against the law!"

The second question asked was *"In your experience and expertise, what are the necessary requirements for the successful implementation and operation of shared micro-mobility services, particularly in Malta?"* The aim of this question was to understand the participants' opinion on what is needed to successfully implement shared micro-mobility services in Malta. Additionally, this question helped answer Research Question #2 and help determine those conditions that are necessary to sustain a shared micro-mobility service in Malta.

Results of the second question are demonstrated through a sunburst pie chart in Figure 8. The scope of a sunburst chart is to group the responses together and segregate them into categories and/or subcategories, where applicable. Moreover, through reviewing the transcriptions of Question 2 of all participants, the number of times a category or subcategory was mentioned was counted. This determines the size (and angle) of the sector of the pie chart, which in turn demonstrates the frequency at which a requirement was mentioned by the participants during the interviews. And hence, the size of the sector also demonstrates a requirement's importance, and need, to be implemented in order to obtain a successful shared micro-mobility service in Malta.

Figure 8 – A sunburst pie chart showing the necessary requirements needed to be implemented for a successful shared micro-mobility service in Malta.

As can be seen in Figure 8, the most important requirement category for shared micro-mobility is service, particularly the need for better enforcement and controls as well as service restrictions. Enforcement can take the form of human and technological enforcement. Enforcement requirements may also include protective garments, such as helmets and gloves. Service restrictions include restrictions on main roads, speed limitations, restrictions in pedestrianised areas as well as age restrictions. Additionally, it was remarked that the shared micro-mobility services need to be safe, accessible, available and cheap, while also requiring a comfortable space for people to be trained or learn how to use such modes of transport. One service provider stated that they do "first-

try academies" for example, which are schemes provided by service providers to offer the space to train users the first time they subscribe or make use of their service.

The second most important requirement category is infrastructure. One participant claimed that "road infrastructure needs to have heavy improvements for shared micro-mobility scooters to be used on our roads". Infrastructure for shared micro-mobility can take various forms. The most mentioned were segregated lanes for bicycles and e-scooters. Moreover, these lanes need to be networked in such a way that makes sense leading to main nodes as well as to each other and not constructing lanes in isolation. One respondent highlighted that such lanes "are lacking and disjointed, you use a lane for a kilometre, but it ends nowhere". Such lanes need to be regularly maintained, through regular sweeping of soil or dust, clearing of mud and trimming of overhead branches, while ensuring appropriate crossings are streamlined and easy to use. The same participant gave the example of the Marsa junction lifts and crossings – "Instead of doing a subway, which is what is usually done in other countries, they decided to put lifts! So, the lifts fail, that means you have to walk up the stairs or wait for someone to come service and fix the lift. It's a waste of time". Other infrastructure is allocated parking for these modes of transport. One participant remarked that parking should be more regular, "there needs to be a constant number of stops, every 100m for example". Another participant said that parking is cheap and "are very quick to do, paint and a pole or sign – done". Additional facilities that were mentioned were mobility hubs at key node points of interchange of various modes of transport, which also provide water stations, vending machines, parking spaces and other amenities. Shower facilities in offices were also mentioned.

A change in the social perception and acceptance of shared micro-mobility services was the third most important requirement category noted by participants. This primarily starts from the change in mentality and culture, including acceptance amongst other road users. Moreover, educational campaigns are essential to educate our youth and population about this alternative mode of transport and the importance of sharing the road. One participant said that campaigns can help "show people where to go through, how to use it and how easy the process is". Activities organised solely by or in collaboration with, service providers, NGOs and the associated government ministries, can help improve the social perception of shared micro-mobility. Finally, political will amongst local politicians was also mentioned to change the social perception to

recognise shared micro-mobility as a solution to local transport problems and commit to long term solutions and projects to sustain micro-mobility.

Transport management was the fourth most important requirement for shared micro-mobility. Transport management includes various elements that need to work together; these include the proper implementation of policies and regulations. It also includes car disincentives, with respondents stating that "currently the private car is the most attractive, but it is the least sustainable", and "the private car is the worst form of transport that there is." Car disincentives include increased taxes and insurance, parking fees, reducing speed limits for cars and restricting cars in village cores, pedestrianised zones and lanes dedicated for micro-modes of transport and mass public transport. Integration amongst services, including other transport systems was also deemed necessary for transport management. The need for more pilot projects and local council level projects was also highlighted, allowing the space for experimentation and learning prior to launching a service on a national level, while also allowing time and space to understand the market and adapt the service to our specific local requirements and culture. One participant highlighted the fact that "although we are a very small country, localities vary in characteristics". Better engagement and collaboration amongst stake-holders to form better integration and more financial incentives from the government or the workplace were also highlighted.

The third question asked was *"What were those attributes that led to shared micro-mobility leaving the island?"* The aim of this question was to understand the participants' opinion on what were the determinants and attributes that led to services such as Bolt and Bird e-scooters and Nextbike bicycles to abruptly halt their services and leave the islands. This will answer Research Question #3.

Results for the third questions are shown as a bar chart in Figure 9. The scope of the bar chart allows one to immediately visually understand those main attributes that led to such services leaving the islands. Similarly to Figure 8, through reviewing the transcriptions of Question 3 of all participants, the number of respondents mentioned a reason was counted. This determines the size of the bar of the bar chart. The reasons were ranked, with those having a higher score towards the left of the bar chart.

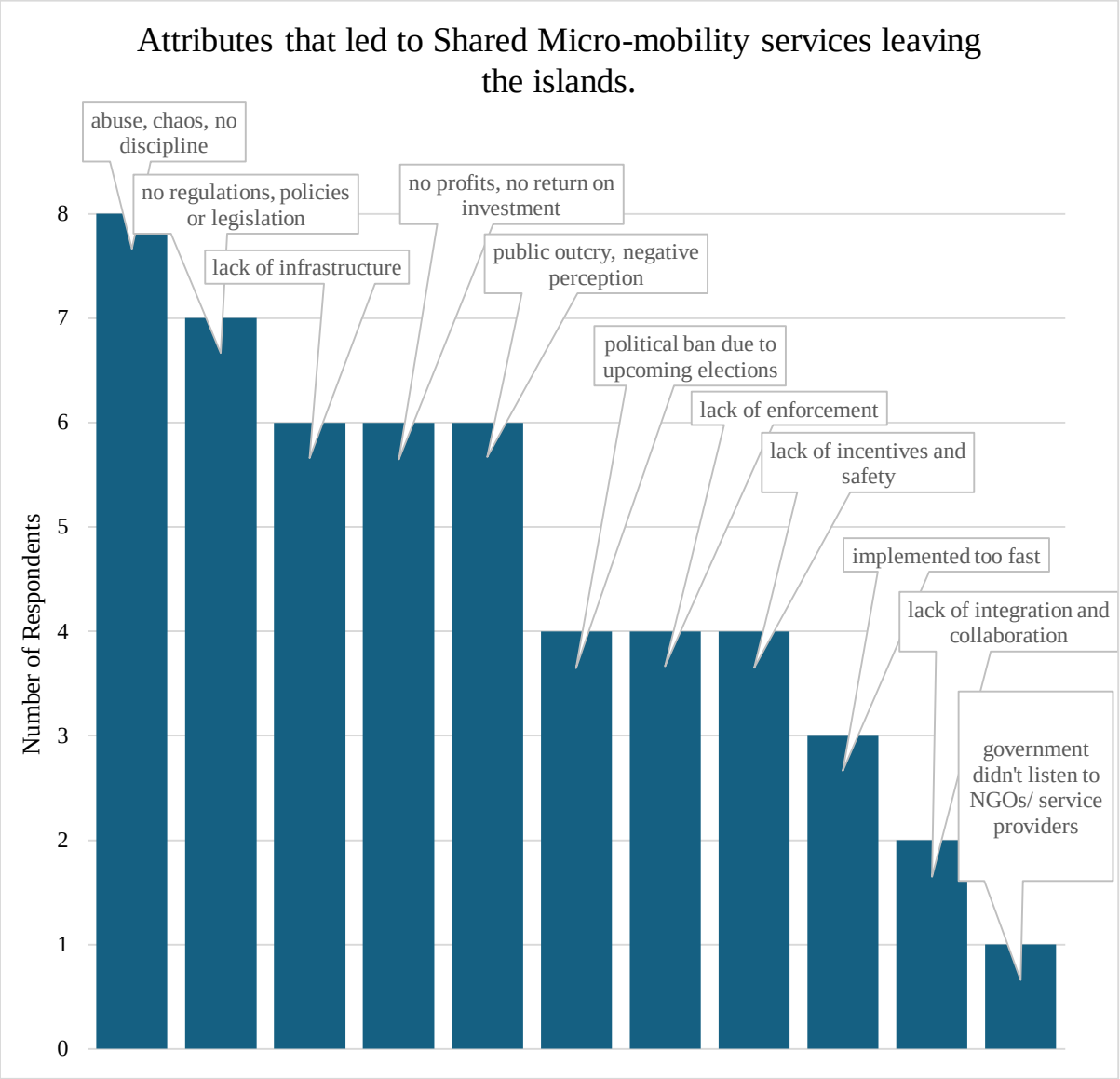

Figure 9 – Reasons that led to shared micro-mobility services leaving Malta and Gozo.

As can be seen in Figure 9, the top reason that was identified by the interviewed participants was the abuse, chaos and lack of discipline amongst micro-mobility users. This was mentioned by eight respondents. Respondents complained that e-scooters were left "lying around on pavements". Such behaviour by micro-mobility users led to bad parking habits and dangers for other road users. Seven respondents replied that there were no regulations, policies or legislation in place to govern the management of shared micro-mobility services. One might suggest that this led to the chaos and abuse highlighted as the main reason. When one compares Figure 8 and Figure 9, one can tally between the reason of chaos, abuse, no discipline and no policies or regulations and the most necessary requirement for shared micro-mobility services in Malta. This was for the service to have enforcement, controls and specific restrictions.

Six respondents pointed to the lack of infrastructure as an attribute that has led to shared micro-mobility services leaving the islands. Once again, comparing Figure 8 and Figure 9, one can tally between the reason of lacking infrastructure to infrastructure being the second most important requirement.

In addition, six respondents also highlighted the negative perception and public outcry as the reason that has led to shared micro-mobility services leaving the islands. This public perception was derived from the abuse, chaos and no discipline previously mentioned. Comparing between Figure 8 and Figure 9, one can tally between the reason of a negative public perception to a change or acceptance of social perception of shared micro-mobility being the third most necessary requirement to sustain micro-mobility services in Malta.

Interestingly, six respondents also gave the reason of service providers not receiving profits or return on their investments. Suggestions as to why this was the case were, because Malta is a small country and small population, assets were prone to vandalism, and we have a culture of owning cars. One remarked that "we are an inactive people, who are highly dependent on cars and simply do not like to walk". A service provider claimed that "the fees are so low but the costs are so high". In fact, one service provider in Malta stated that "I can't say it's a very successful story from what we're seeing so far, it is not giving us the results we would like to see", claiming that such services are "still difficult to promote". Another service provider continued to say that there are "no plans to increase the service, not immediately but we don't exclude it".

Four respondents pointed to the lack of enforcement and lack of incentives and safety. One highlighted that road safety requires enforcement, for example when road works are happening – "sometimes we forget to allow a place for people to walk!" One participant even claimed that "the government is not interested in micro-mobility or active commuting". They continued to say that although it is good that there are current incentives to buy e-bikes, however, the "roads are inherently dangerous, there is no protection, drunk drivers drive like crazy while on the phone, the roads are of bad quality, there is no safety, so of course people are going to use their cars." Another participant who is also a cyclist also stated that "I am very aware of how vulnerable I am".

In addition, four respondents blamed the political ban of e-scooters that led to shared micro-mobility services halting operations. To further analyse this topic of the e-scooter services ban in March 2024, through reviewing the whole interview transcriptions, a pie chart (as shown in Figure 10) was generated to show the participants' opinions whether they agreed or disagreed in the e-scooter services ban in Malta.

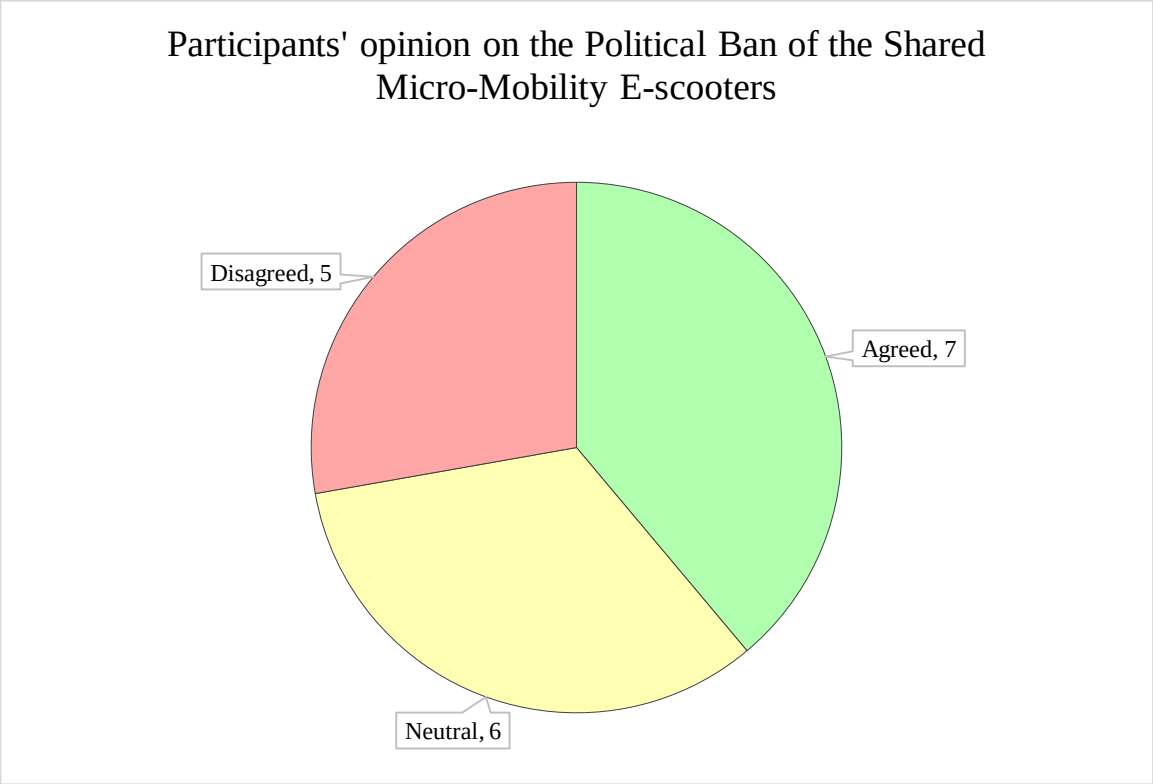

Figure 10 - Pie chart showing the opinions on the ban of shared e-scooter services.

As can be seen in Figure 10, seven out of 18 participants showed that they agreed with the ban, with one clearly claiming, "I wouldn't want them back" and that "we're better off without them". One also claimed that the solution "had to be drastic, because everyone did whatever they wanted". Meanwhile only five out of 18 participants showed clear disagreement with the ban. Some participants blamed the upcoming EU and local councils' elections at the time of introduction of the ban, while another participant claimed that "this abrupt halting of services has completely eradicated the chance for future businesses or entrepreneurs to come and create something better or even more innovative. It would have made more sense for the government to phase out this sector, giving investment to plan ahead". Six out of 18 participants took a neutral stance and did not show a clear opinion on the ban of e-scooter services in Malta. The number of participants who agreed with the ban came as a surprise, considering that 15 out of 18 respondents had a positive perception of shared micro-mobility services in Malta (refer

to Figure 7). This clearly shows that although having a positive perception, the problems of shared micro-mobility services in Malta were so great and have escalated beyond control, and there was significant public outcry that the ban was deemed necessary, by those respondents.

Referring back to Figure 9, three respondents commented that shared micro-mobility services were implemented too fast, ahead of their time. Respondents claimed that they were implemented prior to having an appropriate framework, regulations and legislations in place. One respondent claimed that the market gaps remained unknown. This tallies with the necessary requirement of having pilot projects on a small scale prior to implementation on a national level.

Two respondents replied that the lack of integration and collaboration amongst stakeholders were the reason why shared micro-mobility services left the islands. One participant claimed that "sometimes I feel like [stakeholders] don't talk, and work separately". Finally, one respondent replied that the government simply did not listen to any NGOs or service providers on the matter.

Finally, the fourth question asked during the semi-structured interviews was *"Can you elaborate on what you foresee as the successful implementation of shared micro-mobility services in the upcoming years in Malta?*

a. *What recommendations can you provide for the future successful implementation of shared micro-modes of transport?*
b. *Or what alternative recommendations can you provide for future sustainable transport?"*

The aim of this open-ended question is to gather the participants' recommendations for the future successful implementation of shared micro-mobility services in Malta. This answered Research Question #5 and collected the recommendations from all stakeholders who participated in this study. An additional question was asked in order to gather other recommendations for sustainable transport in Malta, in general. Results for these recommendations of shared micro-mobility services and sustainable transport in Malta are shown in Figure 11 and Figure 12, respectively.

Figure 11 is a Tree-map chart showing the recommendations participants provided for shared micro-mobility services if they had to be reintroduced in Malta. The scope of a Tree-map chart is to group recommendations together and segregate them into categories and/or sub-categories (also known as branches or leaves), where applicable. The size of the 'boxes' are determined by counting the number of times a recommendation was mentioned through reviewing the transcriptions of Question 4a, of all participants. And hence, the size of the 'box' also demonstrates a recommendation's importance to be implemented in the opinion of the participants. It should be noted that the highest frequency recommended actions represented as a 'box' are sorted to be at the top left of the chart.

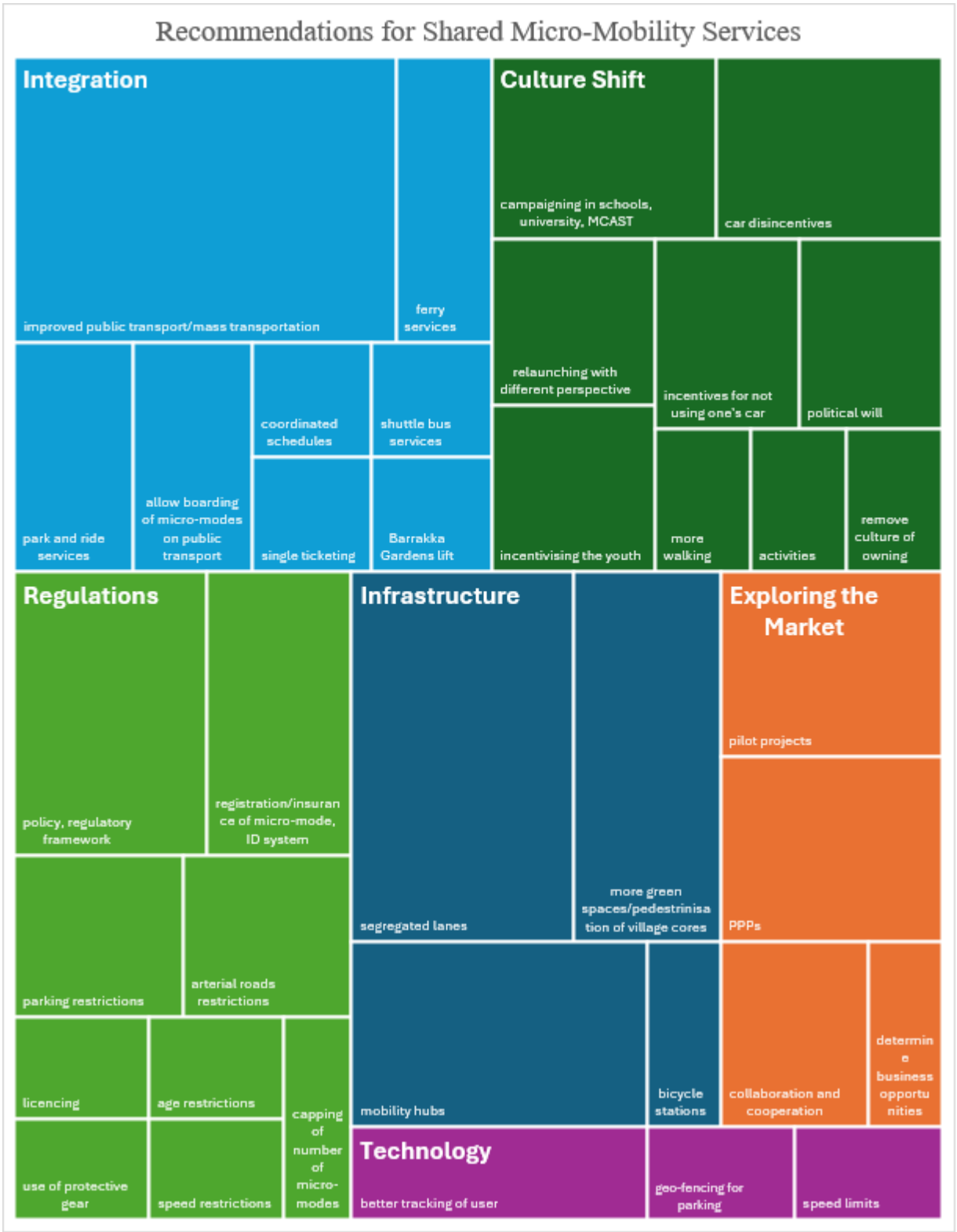

Figure 11 – Tree-map chart showing the recommendations participants of the semi-structured interview gave to successfully implement shared micro mobility services in Malta.

Recommendations were classified in categories for ease of presenting the holistic number of recommendations provided by participants from Question 4a. As can be seen in Figure 11, the largest number of recommendations were related to the integration of shared micro-mobility services with present modes of transport. This was followed by recommendations for cultural shifts, the implementation of regulations, infrastructure for micro-modes of transport, exploring the market, and technology.

As shown in Figure 11, integration of shared micro-mobility with several modes of transport were recommended. In fact, not only were suggestions for integration the most common category, but eight respondents replied that the first recommendation to re-introduce shared micro-mobility services, is for Malta to have an improved public transport mass transit system. This is the most common recommendation received from Question 4a and is also shown as the largest 'box' in the Tree-map chart. This suggests that many perceive public transport as a good solution towards transport management in Malta, but public transport requires improvements to remain competitive with other modes of transport. Many responded that shared micro-mobility makes sense if a good public transport system is provided. One understands that there cannot be bus stops in every road and corner and hence, respondents quoted the last-mile approach and application for shared micro-modes of transport. Public transport can take commuters long distances, while shared micro-modes of transport will allow people to travel from bus stops to their required destination. This answers the question put forward when in the results of Question 1, seven out of 18 respondents stated that shared micro-mobility is only one of the solutions (refer to Figure 7) and the question put forward was "What else is required?" The answer is clearly shown here in Figure 11, where an enhanced public transport system is required to go hand-in-hand with shared micro-mobility services.

Integration with other modes of transport was also recommended, these included ferry, park-and-ride and shuttle bus services. Moreover, other logistics recommendations were also suggested, including having it easier and allowing commuters to carry micro-modes of transport, such as e-scooters and bicycles on public transport or the Valletta Barrakka Gardens lift. Additionally, having coordinated schedules and single ticketing system was also recommended.

The second most recommended category were suggestions related to changing the mind set and cultural shift. Although only two participants out of 18 had a negative perception of shared micro-mobility, one cannot ignore the negative perception of these modes of transport amongst the Maltese population. One respondent followed up by saying "our recent past experience may have created a misconception about all this". Following the experience of shared micro-mobility services in Malta, which led to chaos, abuse and lack of discipline, which were highlighted as the main reasons why such modes of transport left the island (refer to Figure 9) one can understand why the perception towards them is rather negative. More so, when only five out of 18 respondents disagreed with the ban of shared micro-mobility services. So, it comes as no surprise when several recommendations for a cultural shift were suggested during the interview.

The main recommendation was increasing campaigns promoting active modes of transport. One participant stated that "I do question if it is even being promoted or the desire to use such a mode of commuting is solely coming from a rider's personal initiative..." Campaigns should not be restricted to schools and university, but also through online and TV adverts highlighting the importance of micro-mobility. Recommendations for an increase in incentives for youths and for one to reduce the usage of their cars were also mentioned, to invite and encourage people to make use of more active modes of transport. One also suggested the need to work to remove this culture of owning cars that we have in the Maltese Islands. Two respondents highlighted the need to relaunch shared micro-mobility services with a different perspective. Especially considering the negative perception towards these services, a good relaunching strategy must be in place. Unfortunately, one respondent went on to say that "in these past years we lost an opportunity in this area" and "now it would be very difficult to reintroduce them without causing some sort of uproar". Activities to promote micro-modes and active modes of transport with collaboration between service providers, NGOs and transport entities was also suggested. Furthermore, the need for political will, amongst the main political parties, was also necessary. One participant insisted that we need to "leave that populist idea centring around cars". This not only ensured long term support but also ensured long term transport strategies and infrastructure projects are implemented successfully.

One respondent highlighted the need that as a nation we need to walk more. Another recommended introducing a walking policy. Highlighting Malta's size, by simply walking, commuters can also contribute towards a more active lifestyle and contemplate on the use of micro-modes of transport instead of their private car.

As part of changing the culture, four participants highlighted recommendations for car disincentives to promote the use of shared micro-mobility services. These include parking meters, segregated lanes and slow streets. In fact, as one participant said, "what's going to disincentivise people from using a car is to be stuck in a traffic jam and seeing an e-scooter zoom past on a safe path near it".

As can be seen in Figure 11, the third most common recommendation category was related to the implementation of regulations. Enforcement and controls were deemed as the most necessary requirement for the successful implementation of shared micro-mobility in Malta (refer to Figure 8). Moreover, seven respondents clearly stated that the lack of regulations, policy and legislation resulted in shared micro-mobility leaving the islands (refer to Figure 9). So, it comes as no surprise that recommendations for regulations were popular amongst interview participants. Several highlighted the need to ensure sufficient policy and regulatory framework are in place. Several also recommended the need to implement forced registration, an ID and licensing system for micro-modes of transport. This will be helpful for insurance and accident purposes, whilst also ensuring vehicles are being used by people who are not under-age and know the local road regulations through obtaining their license. Parking in pre-defined parking areas was deemed as mandatory, while also restricting users to use micro-modes of transport on regional roads, a common sight seen in Malta.

In addition, the use of protective garments, such as helmet and gloves, were also suggested to safeguard the users and reduce injuries. Speed restrictions in certain pedestrianised areas was also deemed as mandatory to safeguard pedestrians walking along promenades or village cores. Finally, the capping of the number of shared micro-modes of transport in a particular area was also suggested in order to not create a public nuisance and reduce the visual impact, especially in historical or scenic areas.

Following regulations and controls, the fourth most common recommendation category was related to infrastructure. More so, the second most common recommendation from all of Question 4a. (and shown as the second largest 'box' in Figure 11) is the

implementation of segregated lanes. Six participants gave this suggestion. One NGO representative went on to say, "what the government needs to do is, which would be very unpopular, they need to take away a lane or two and simply convert it, strictly and not only with spray paint but proper safety barrier into a segregated bus lane or micro-mobility lane for people to use. That is the only way forward". Additionally, more green spaces and pedestrianised areas were deemed necessary to allow safe use and access to village cores and promenades with the use of micro-modes of transport.

Mobility hubs for people who use active or public transport was another suggestion. By linking with integration of modes of transport, having such mobility hubs will allow people to move better and choose between options. Such mobility hubs can be located at key nodes in regular commutes, such as prominent bus stops and ferry terminals. These hubs can provide information, toilets, water stations as well as parking bays for both personal and shared micro-mobility services. One participant also suggested having maintenance posts for maintaining one's bicycle (for example to fix punctures or pump up tyres). There can also be charging points for e-scooters and e-bikes, which can be accompanied with cafés or vending machines, commonly seen in petrol stations across the islands. In addition, another suggestion was to have more bicycle parking bays, which should be more popular around the islands, including areas near offices, for those using their private micro-mode of transport. These can be monitored with security cameras to avoid theft and vandalism as one participant claimed that "you wouldn't trust to leave your e-bike anywhere".

Several participants highlighted the need for exploring the market and understand, using pilot projects, Public-Private Partnerships (PPPs), collaboration and cooperation, how micro-mobility should be implemented. These options should be in place in order to understand the market gaps, understand "not only what is needed but what do the commuters want" and if they perceive value in shared micro-mobility services. The need to understand the business opportunities was also highlighted, including the need to provide a space to experiment, gauge the extent to which shared micro-mobility services should be implemented and determine the particular requirements Malta exhibits and allow time to adapt, if necessary, before launching on a large national level. In terms of collaboration, one service provider said "We need to speak to each other, we need to build this together. If we don't it will fail. We need to have an understanding of our

common interests and disinterests. To find the middle ground. Very quickly we will find that we have more common interests than negative interests".

In line with business opportunities, the advance in technology is one which cannot go unnoticed. One participant explained that the e-scooters we used to have in Malta before the ban are outdated and cities across Europe have done away with these vehicles. E-scooters nowadays are made stronger, more durable and of more environmentally friendly materials that do not degrade as much if thrown in the sea or nature – this to reduce leaching of unnatural substances in natural habitats. They are more susceptible to wear and tear and vandalism or improper use. There are more systems in place to ensure batteries are not easily stolen. Suggestions for technology systems include better collection of data and tracking of users and their daily routes and patterns to create a heat map and understand the main roads and nodes used. Other technologies include speed limitations and more advanced geo-fencing for parking. Triangulation and monitoring can also allow scooters to be found in remote areas even though they may be offline.

Finally, Figure 12 shows the last results of Question 4b. Represented through a pie chart, the recommendations for future sustainable transport are represented. Once again, the size of the sector of the pie chart are determined by counting the number of times a recommendation was mentioned through reviewing the transcriptions of Question 4b, of all participants. The number of participants who suggested a recommendation are also shown in the data labels.

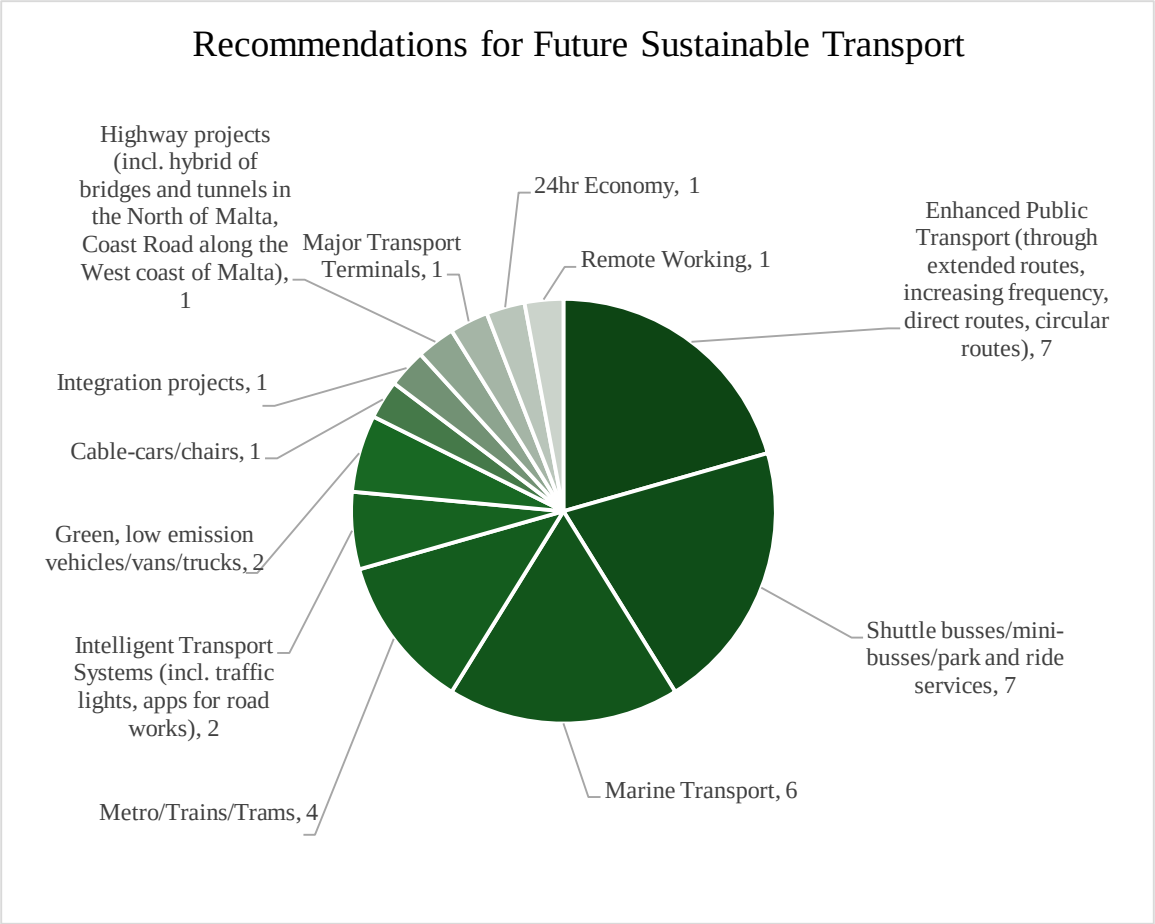

Figure 12 - Pie chart showing the recommendations participants of the semi-structured interview gave for future sustainable transport in Malta.

Seven respondents highlighted that Malta urgently requires an enhanced public mass transport service. One respondent claimed that they "receive a lot of complaints from people who wait for a bus, which misses its designated time, or they don't come, or a bus is sometimes skipped, and they have to wait a whole other hour or 30 min" while "buses get stuck in the same traffic as private cars". Improvements include extended routes, increasing bus frequency as well as implementing direct and circular routes where applicable. In addition, enhanced mini-bus or shuttle bus services are crucial for other applications, including park-and-ride services to village cores which become pedestrianised.

Six respondents also suggested the enhancement and exploitation of maritime transport and our seas. Considering we are an island, with most villages and towns bordering the sea, and our geography and weather, with most days with sun and protected seas, marine transport through fast ferry services can be an excellent solution for mass transport.

Four respondents suggested trains, metro or tram systems. However, it is widely known that these are "expensive and require long-term commitment". Two respondents suggested the implementation of more intelligent transport systems such as automated traffic lights systems as well as mobile applications to alert and update riders on road works for example.

Two respondents also suggested the use of and push for more green low emission vehicles, vans or trucks. Such modes of transport should be used especially for those who cannot use micro-modes of transport, due to age, disability or simply the type of trip, for example those going for their weekly shopping trip to the supermarket or for work purposes.

One respondent suggested the use of cable cars or chairs in certain places in Malta; for example, in Valletta to access the cruise terminal. Other nature-oriented applications that were suggested include areas such as Mġarr to access Ġnejna Bay or Żurrieq to access Wied iż-Żurrieq. Such a cable car service will allow access for people, including tourists, while restricting cars to be driven to such natural areas and only allow micro-modes of transport for example. This will not only create a safe space for active modes of transport to be used, but also benefit the natural eco-system and make these natural landmarks more pleasant to visitors.

Another respondent suggested a large infrastructural project to solve the traffic problems of the north of Malta and also reduce road crashes. Through a series of bridges and tunnels direct routes from Ċirkewwa to Mosta can be created, providing safe passage away from nucleated dense settlements of Mellieha, Xemxija, St. Paul's Bay, Burmarrad, Manikata and Mġarr. The same respondent also suggested a similar concept of the Coast Road (spanning Pembroke to St Paul's Bay) along the West Coast, for example from Mġarr, passing by Ħad-Dingli and towards Żurrieq, although they did remark this would be highly unpopular.

Another respondent suggested the implementation of more major land mass transport terminals. Making reference to the Valletta and Marsa bus-terminals, more of these are required in central spacious areas such as Ta' Qali, Pembroke, and even areas towards the North and South of Malta. Direct buses (without any stops) can transport people directly to these terminals, while allowing more frequent circular routes from these terminals to village cores, for example.

One respondent also suggested a change in mentality in how we work, suggesting a 24-hour economy and the increased frequency of remote working. Allowing people to work from home, where applicable and if the type of work allows it, reduces significantly the amount of traffic, especially during rush hour, to and from the workplace. Not only does remote working reduce traffic but it also reduces the air pollution and fuel consumption. One respondent gave the example of Covid-19 lockdown when the "air pollution levels actually went down". In addition, a 24-hour economy allows flexibility of work, allowing persons to decide for themselves and manage their working hours throughout the day, balancing their needs and errands, while also reducing the impact on the peak rush hour.

4.1.1. Reference to the use of Micro-Mobility in recent projects

During the semi-structured interviews, several participants gave examples or followed up their answers referring to several infrastructural case studies in Malta which circulated around the need for green spaces, pedestrianisation of areas, diverting private vehicles and promoting micro-modes of transport. It is interesting to analyse these projects, which are current affairs and particular to Malta. One can understand what worked, or failed, and what the lessons learnt from these projects are, to further supplement the results of the interviews. These case studies are summarised below:

The Msida Creek Project

The Msida Creek Project which is currently (2025) in progress, sparked several comments from participants. The ambitious project is an infrastructure development involving the construction of a flyover (as shown in Figure 13) and incorporate facilities for alternative modes of commuting including cycling lanes, as well as the upgrade and embellishment of surrounding and recreational areas [78].

Figure 13 - Proposed Msida Creek Project showing the Flyover from Skate park toward Pieta/Valletta, and new cycling lanes (with light green paving) *[78]*

One participant stated that “it is short sighted” while another stated that “it just doesn’t make sense at all, especially since there’s a flyover splitting a locality in half!” One went on to say that it will be difficult for pedestrians and active commuters to commute between University of Malta or Junior College, stating that “people will need to go up lifts and steps”.

However, one respondent said that the "project will be quite positive" as "there is a good allocation of public spaces and cycling lanes". They went on to say that it is a "green project" which will have "a lot of benefits to the Msida area". However, they did remark that "obviously, a lot of things can be done better", that is why "there was the consultation period before the project was approved".

When asked to elaborate on car disincentives and diverting cars, to provide safe corridors for micro-modes of transport, the same participant replied "you can't have a project without cars, Malta still has a high use of private cars and taxis, cars are an important element, and yes, it has to be a project that can accommodate cars". They went on to say that "the idea is that while we still have roads for cars, we still have space for other modes of transport". The participant went on to say that "the culture is what it is, cars will still be used, you can't simply stop them".

The Mosta Rotunda Pedestrianised Project

Two participants brought up the topic of the Mosta Rotunda pedestrianisation project, shown in Figure 14. The new square, in one of the busiest areas in the heart of the island, still allows traffic to pass through, however it is designed to allow the local council or authorities to make it fully pedestrianised for a day or during the weekend [79].

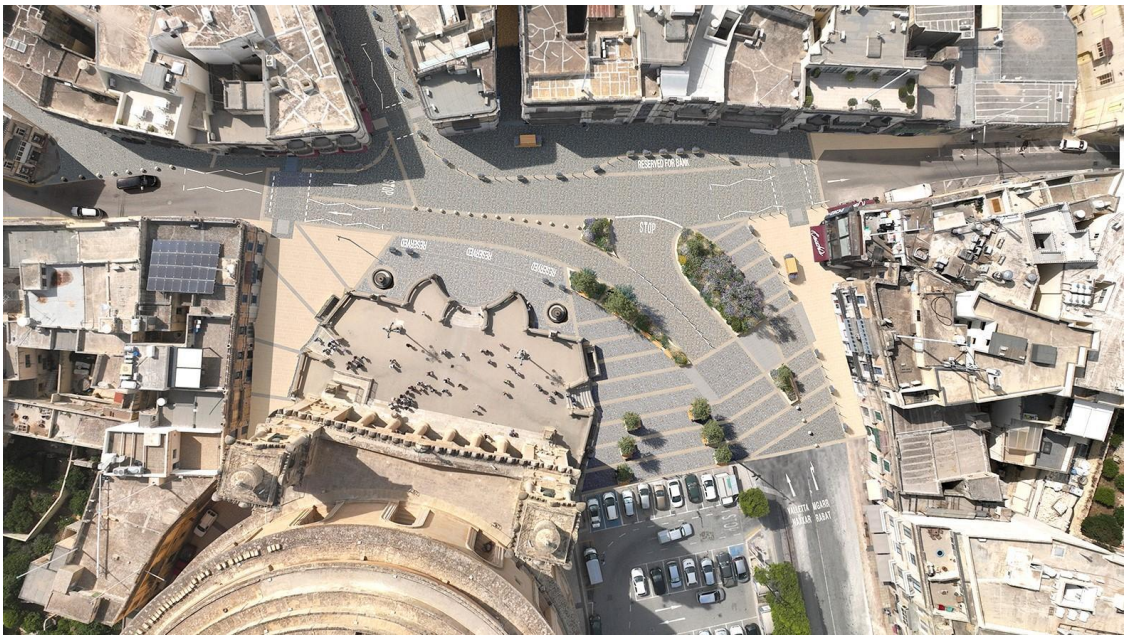

Figure 14 – Aerial image of the new Mosta square, still showing lanes for car access *[79]*.

One participant claimed that it was done “in isolation”, while another NGO representative went on to remark that “it was done without any plan”, “half-heartedly” and that “ideally [they] introduced trees (actual trees not planters), benches to incentivise people to use the space”. The resident went on to say that “it is currently a road that is closed off at certain times” and people see it as an “empty car road”, and remarked that “the environment isn’t pleasant”. The participant went on to say that not enough time was given to see its success, he claimed that people need time, to get used to it and reclaim their spaces and “culture takes time to change”. He went on to say that such a project “doesn’t mean restaurants should expand their tables and chairs in the spaces either!” The participant also brought up a similar project of Rahal Ġdid calling it “a shame”.

Remarking on pedestrianisation projects around Malta for safer micro-mobility corridors, the participant went on to say that “other countries have managed” and “we are not reinventing the wheel”. It is true people will complain because they do not have “maximum convenience” with their cars, however as a result “everyone is suffering” including active commuters. He provided solutions such as timed pedestrianised areas to allow residents to park or leave from their garages at particular times. He concluded by saying that the situation in Mosta “became a political football between the two parties”.

4.2 Sustainability Assessment

Shared micro-mobility services and active modes of transport are analysed to determine their sustainability. Sustainability is defined through the three pillars of sustainability which includes the environmental, economic and social pillars. Comments and points addressed through the semi-structured interviews, related to the sustainability of shared micro-mobility are listed below in Table 3, 4 and 5. Although the interview questions did not require participants to comment on the sustainability of such modes of transport, several participants elaborated on such topics.

Environmental Pillar	
Advantages	Disadvantages
Shared micro-mobility are Eco-friendly.	Shared micro-mobility are an eye-sore and have a negative visual impact to the environment.
Shared micro-mobility equipment is physically smaller and make use of less resources in comparison to a privatised cars - reduces resource depletion.	Vandalised micro-mobility assets in natural ecosystems or thrown in the sea affects the natural habitats and cause leaching of chemicals.
Shared micro-mobility are electric, can be powered from green renewable sources of energy.	Shared micro-mobility services still require energy, which may not come from green energy sources and may still have a carbon footprint.
Making use of green sources of energy reduces emissions and air pollution.	Electric active modes of transport make use of batteries which have a life span, require replacing and have chemical properties detrimental to the environment.
Shared micro-mobility have a lower carbon footprint; they are cleaner and contribute to achieving Carbon Neutrality	The movement of assets from one locality to another to supply demand requires vans which may not be electric and have a carbon footprint.
Less noise pollution	The production and assembly of assets in overseas factories and distribution/shipment to Malta still has a carbon footprint.
For solo short trips, shared micro-mobility are more energy efficient.	Misuse of shared micro-mobility services can significantly reduce the life span of an asset, requiring more spare parts and replacements of assets as well as scrap.
Shared micro-mobility helps reduce cars on the roads and traffic congestion for short trips. This in turn further reduces air pollution from traffic congestion.	
Overall improved quality of environment and enhancing of ecosystems	
Shared micro-mobility makes use of less space, less impact on infrastructure and parking spaces.	
Replacing cars with micro-mobility reduces the demand of agricultural land for wider roads.	
Modern shared micro-modes of transport are becoming more modular; that is, it is easier to repair parts instead of discarding parts or vehicle – reduces overall resources	
Being modular, portable batteries are being used to charge scooters instead of physical carrying vehicles to charge - reduces air pollution	

Table 3 - Comments from the semi-structured interviews regarding the environmental pillar.

Economic Pillar	
Advantages	Disadvantages
Shared micro-mobility provides a business opportunity, profits and jobs.	Shared micro-mobility services require effort, investment, maintenance costs and operational costs – high capital costs by the service provider
Shared micro-mobility can contribute towards the tourism and sport industries.	Shared micro-mobility services and active modes of transport requires effort, skill and time from regulatory and government entities to create regulatory frameworks and policy, which are complex.
Micro-mobility modes of transport are a convenient option for short trips.	Campaigns to promote active modes of transport requires effort, cost, advertisements and time.
Cheap fee for the user.	Micro-mobility requires infrastructure which takes up road space, a challenge in Malta for road design and capital infrastructure entities, since road space is limited and competitive.
Micro-modes of transport are cheaper than a private car, no need to purchase a garage – cost effective for the user.	Shared micro-mobility services are prone to vandalism, misuse, more wear and tear and damages to assets. An additional cost for service providers.
Shared micro-mobility services allow users to share assets and not purchase – cost effective for the user	Additional technology and monitoring schemes to monitor usage and prevent vandalism are a further cost for service providers.
Shared modes of transport reduce maintenance and fuel costs/effort for the user	Improperly parked shared micro-mobility scooters can cause scratches, dents and damages to other assets, including cars – an additional cost and hurdle on 3rd party persons.
In the case of shared micro-mobility services, assets are shared and allow several users using the same asset in a day - profitable for the service provider.	Difficult for service providers to obtain an insurance policy as it is hard to keep track of who is responsible for the damage of 3rd party assets (as the last rider may have parked appropriately but the e-scooter may have been moved, kicked or toppled over by a passer-by)
Integration with other modes of transport (e.g. bus service) benefits other services and can lead to further profits for all transport service providers.	Shared micro-mobility services require movement of assets from one locality to another to meet demand.
Micro-mobility vehicles can be picked up on other modes of transport (e.g. fast ferry services) – enhancing integration and profits.	If shared micro-mobility services require parking spaces, charging points, etc. this is taken up from current parking spaces of vehicles or public space.
Micro-mobility requires smaller, cheap infrastructure in comparison to other modes of transport.	Shared micro-mobility services require effort to charge assets, either by collection or replacement of batteries.
Micro-mobility are light weight vehicles and do not require expensive, heavy, robust infrastructure.	
Micro-mobility reduces traffic congestion – less time spent waiting in traffic	
Shared micro-mobility services are easy to use, convenient and available, attracting numerous users.	
Micro-modes of transport can be integrated, monitored and regulated using technology, e.g. parking, speeding and measuring KPIs.	

Table 4 – Comments from the semi-structured interviews regarding the economic pillar.

Social Pillar	
Advantages	Disadvantages
Shared micro-mobility offers an alternative, diversified, mode or method of commuting.	Active modes of transport cannot be used by all persons, persons with disability and mobility constraints cannot use such modes of transport.
Shared micro-mobility is versatile, users can opt (or adapt) for micro-mobility depending on the type and distance of commute.	Improperly parked shared micro-mobility vehicles are an obstacle on pavements which can result in pedestrians tripping and injuring themselves.
Shared micro-mobility allows users to use more scenic routes and can be fun.	Improper parking of shared micro-mobility vehicles in front of garages or residents are a nuisance and hinderance to 3rd party residents.
Shared micro-mobility allows users to by-pass traffic.	Improper use of shared micro-mobility vehicles on promenades and streets by users poses a danger to pedestrians and passers-by.
Avoids/No parking problems	Improper use of active transport, by swerving through traffic, speeding, running through red lights and zebra-crossings, passing against traffic are more prone to cause a danger on the roads, accidents and additional road rage.
Overall improved quality of life	
Better infrastructure/connectivity for shared micro-mobility is beneficial to pedestrians and persons with disability	Users who use shared micro-mobility services are more prone to dangers in comparison to a car especially when they do not use protection gear – they are prone to injuries on the head and limbs.
Improves users' physical health: Shared micro-mobility allows users to become more physically active (cycling, walking and movement). Shared micro-mobility can be used for sport/active commuting. Shared micro-mobility does not reach high speeds (in comparison to motorcycles). This leads to less danger, less injuries in case of collisions & accidents; safer. Users opting for shared micro-mobility reduces traffic, which in turn reduces pollution, resulting in lower respiratory and cardiovascular diseases	Shared micro-mobility services were prone to vandalism and were unsightly.
Improves users' mental health: Shared micro-mobility promotes community engagement, a sense of belonging, reduced social isolation and changes in lifestyle (meet people, ride with friends, able to easily stop to look at shops/speak to friends) Less time in traffic reduces stress/anxiety/road rage Shared micro-mobility improves social mood.	

Table 5 - Comments from the semi-structured interviews regarding the social pillar.

Participants also made remarks on the life cycle of shared micro-mobility services and assets. A simplified life-cycle analysis is provided below based on their comments, particularly from the service providers, who participated in the interview. To demonstrate the lifecycle of shared micro-mobility vehicles such as e-scooters and e-bikes, and the processes such vehicles go through, the following flow chart was created, as shown in Figure 15.

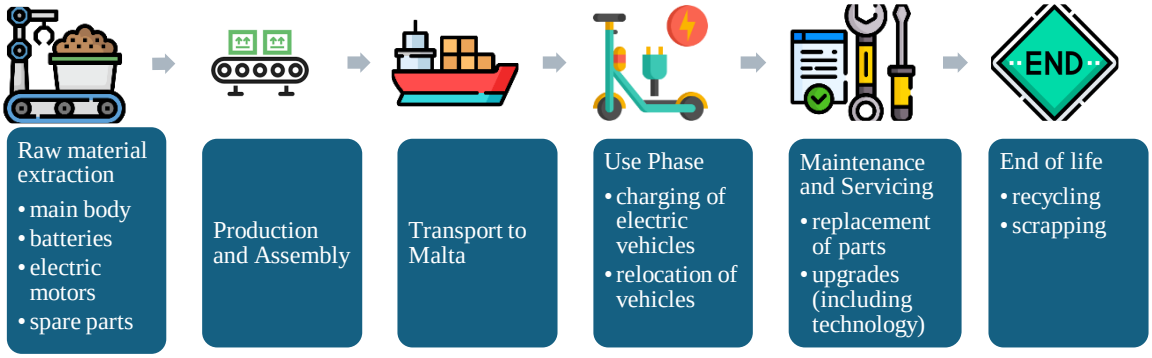

Figure 15 - Life Cycle of Shared Micro-Modes of Transport.

A service provider explained that although they produce their e-scooters abroad, "[they] produce the spare parts close to the markets where they are used" in order to reduce the distribution length, costs and pollution as much as possible. Even during shipments of assets or parts, "we stack them now in ways that save us as much space as possible".

When discussing the use of the product, it was claimed that "shared vehicles can be conveniently used by a limited number of persons per day, reducing the impact of the pollution that is necessary to create these assets". They went on to say that they are "environmentally friendly if they are used multiple times a day". One service provider went on to say that such modes of transport "will naturally be used multiple times per day because of the dense population and the lifestyle of people who move around. In rural areas it makes less sense, from experience".

However, another respondent claimed that "scientifically, through Life Cycle Analysis (LCA), you will find that the carbon footprint of shared scooters to be much higher than those of private scooters". The participant went on to explain that this is not only because of the shorter lifetime of the product due to misuse and vandalism, but also due to the fact that in Malta, shared micro-mobility scooters used to be relocated from one locality to another to supply demand everyday using a diesel trucks. This was not only done for

relocation purposes but also for charging and maintenance purposes. The participant went on to explain that "personal scooters would have lower carbon footprint than shared scooters, because with personal scooters you would charge them at your point A or B, you don't need to include other points". Moreover, the participant went to explain the type of resources and systems used on such micro-mobility vehicles explaining that the use of electric motors and batteries "all have environmental impacts". The participant said that "my scooter only weighs 15kg. That means you have 15kg of material and electric components per person. In comparison to a bus, which carries around 50 people, imagine having 50 scooters, all the resources multiplied by 50!"

The service provider claimed that it is in the interest of the business to have their assets withstand vandalism, misuse and "have assets that last as long as possible". Moreover, the way shared micro-vehicles are designed are that "every single element can be changed" as "repairing these spare parts is even more profitable, instead of replacing" making it more sustainable. In contrast to the other participant, the service provider then went on to say that it is a strategy within their company to improve the relocation of assets from one locality to another by "rebalancing [their] vehicles as little as possible". He simply said that collecting one's assets every night to charge them "is not profitable" and that they make use of electric service vehicles, which are "adapted to [their] assets" and charged from green energy sources to significantly reduce the carbon footprint. It is only done to maintain market share in a locality. He went on to say that each trip is optimised, and a target number of micro-vehicles needs to be reached for each trip to ensure no space or effort is wasted. Regarding charging of assets, the service provider claims that their company makes use of "portable batteries". He said that riders "leave [their] assets where they are and [they] just swap the batteries". He went on to explain that the company has "tiny rooms which contain dozens of batteries where you take them and charge them". The service provider stated that "it allows you to just transport what needs to be transported, that is to say the energy" which is an interesting insight to look at. Moreover, the service provider stated that future service providers need to have "the option to have contracts with electricity providers, ensuring the energy used for these modes of transport are coming from green sources, with a certified contract". He went on to say that unfortunately, "the electric grid in Malta and policy does not allow that yet".

The service provider went on to say that as a company they are subject to auditors, and they need to show clear proof of their activities and how they are complying to improve their sustainability of the service and reduce certain environmental impacts. Moreover, optimisation is required as “at the end of the day it’s a key attribute to your profit and losses”.

4.3 Policy Review

The policy review of the Transport Malta Master Plan 2025 and the National Transport Strategy 2050 is documented below. The review was done by searching key words such as “shared” or “sharing”, “scooter/s”, “bicycle/s”, “e-scooter” and “e-bike”, in both documents.

In the Transport Master Plan 2025 the words “shared” and “sharing” are mentioned in conjunction with micro-modes of transport. In fact, the phrase “shared mobility services” is only mentioned one time in this document, in *Measure 2.2.2.2 - Develop and Incentivise Schemes To Promote Multiple Occupancy, Smaller Vehicles and Reduce The Need To Travel In Peak Hours* (page 105). The measure explains the problem of peak hourly demands and goes on to explain measures to incentivise commuters to avoid driving their cars during peak periods. One measure is to “encourage the use of smaller, more road-space efficient vehicles” and these initiatives include financial incentives to use “car-pooling or bicycle use”, “central area parking priority for shared mobility services” as well as “rewarding companies implementing ‘Green Travel Plans’”. The measure does refer to “car sharing” and “car-sharing services”. Hence, the term “shared mobility services” is rather vague and is not explicit nor inclusive of shared micro-mobility services. However, the measures go on to explain initiatives and explain how such initiatives can be deployed at a wider level. The word “scooter” was also only found once in the masterplan, within this same measure, which explains incentives introduced at a national level to “use low-powered motorcycles and scooters”. This suggests the first reference made to shared micro-modes of transport within the masterplan. However, it remains vague as the term scooter can be used as another word for mopeds or motorcycles, rather than explicitly to micro-mobility scooters.

However, in *Measure 2.2.2.6 - Develop a National Bicycle/E Bicycle Sharing Scheme* (page 108) there is clear reference to bicycle and e-bike sharing systems. The measure

explains how such systems "are increasingly popular in towns and cities around Europe" and can provide "an alternative means of travelling" for working commuters and tourists. E-bike sharing systems are also referred in the Sustainable Urban Mobility Plans (SUMP) for the Valletta Extended Region as a development item (page 110) and the "Gozo Cycle sharing scheme" in section *3.2.1.3. – Promotion of Cycling* (page 300).

Throughout the master plan, the words "sharing" is seen more regularly particularly to "car sharing", "car-sharing services" or "ridesharing". Moreover, reference to e-scooters is not made in the masterplan but reference to bicycles and e-bikes is made in several measures, however other than those discussed previously these are explicit for personal use rather than sharing services.

Within the National Transport Strategy 2050, the words "shared" or "sharing" in conjunction to shared transport was only seen in one of the guiding principles, *Guiding Principle 2 – Creating Modal Shift* (page 154). Within this principle, the increased private car ownership trends are discussed, which "is resulting in ever increasing levels of congestion" and is "unsustainable". The shift towards more sustainable modes of transport includes "public transport, walking, cycling and other shared and active modes". The principle goes on to explain that modal shift supports economic activity, provides accessibility and mobility, promotes urban sustainability, social development and increased public health. To achieve modal shift, investment in services, infrastructure, spatial planning, education and social marketing are required. This is the only time that shared modes of transport are mentioned in the national strategy document. Once again, it is rather vague and not explicit nor inclusive of shared micro-mobility services.

It should also be noted that the words "scooter/s", "e-scooter", "e-bike" were not found in the strategy document. The only reference to, bicycles and cycling is only made in conjunction with the personal use rather than shared services and any reference to active mobility is given to "walking and cycling" which is non-inclusive of shared services.

The lack of reference towards shared micro-mobility services in the masterplan and strategy document, both published in 2016, shows that the introduction of such services in Malta resulted in the system collapsing as there were no plans or order. One participant of the interviews highlighted that this was not only the case of Malta, and "many cities and countries were left alone completely when companies and industries arrived first in

2018 and 2019". In terms of shared micro-mobility services and concepts, the national strategy document and master plan are outdated to reflect the drastic changes in transport management of these alternative modes of transport.

Chapter 5: Discussion

The following is a discussion of the research conducted. As discussed earlier, the aim of this dissertation was to determine the sustainability advantage of shared micro-mobility services and understand the reasons why such services halted their service in Malta, despite being perceived as sustainable. Following the aim, the research questions were determined as described in Section 3.2.1.

5.1. The Sustainability of Shared Micro-Mobility Services

The first research question was "To what extent are shared micro-mobility services sustainable?" Through literature, shared micro-mobility services such as bicycles, e-bikes and e-scooters displayed a significant sustainability advantage in comparisons to the internal combustion engine cars and electric vehicles. As demonstrated by D'Acierno et al. (Figure 5), the energy consumption and hence, the carbon footprint of e-bikes and bicycles is on average 91% less than that of ICE cars, and on average 82% less than that of EV cars [49]. In comparison, a study in China (Figure 4) showed that bikes have an average of 99% less CO_2 emissions than ICE cars [48]. On the other hand, D'Acierno et al. determined that e-scooters make use of an average of 68% and 35% less energy than ICE cars and EV cars, respectively [49]. When analysing the mass life expectancy ratio per person (Figure 6), as D'Acierno et al. determined, the bike displays the lowest results, followed by e-bike and e-scooters [49]. This tallies with what Calan et al. said, where although e-scooters can be the most polluting micro-mode of transport, e-scooters still have the potential to reduce the GHG emissions from more polluting modes of transport, such as cars or taxis [31].

Hence, literature concludes that shared micro-mobility services can reduce the energy use and carbon footprint and hence, be more sustainable than the overbearing use of private cars, especially in Malta. This tallies with the positive perception of shared micro-mobility amongst most of the interviewees participating in the semi-structured interviews. As shown in Figure 7, 15 out of 18 respondents agree that they are indeed positive, citing many sustainability advantages throughout the interview, presented in Section 4.2.

From the interviews, it can be concluded that several sustainability advantages include shared micro-modes of transport are physically smaller, are light weight, make use of less resources and take up less space. In fact, according to literature micro-modes of

transport weigh an average of 96% less material than ICE or EV cars [31] [49]. Participants also stated that shared micro-modes of transport require less infrastructure and reduce the impact on parking, as well as traffic congestion and air pollution. This is also noted by Zammit [25]. Participants also stated that shared micro-modes of transport improve the overall quality of life and have less impact on the environment and ecosystems. They are convenient for short trips and reduce parking and traffic problems for users. They are also cheaper and easier to integrate with other mass transit mode of transport such as the bus or fast ferry. Such advantages also tally with Maas et al. and Shaheen et al. [6] [24]. Several participants also mentioned that active modes of transport have benefits for one's mental and physical health.

However, some participants did not perceive shared micro-modes of transport as sustainable and made negative remarks claiming them as a nuisance and danger. This tallies with what a survey in Malta, discussed in the literature review, which states there is still a large share of respondents who are unable to accept these new shared mobility services [47].

The sustainability compilation, in Section 4.2, consolidates all aspects related to sustainability on shared micro-modes of transport, gathered throughout the semi-structured interviews and the literature review. As discussed, several advantages and disadvantages of shared micro-mobility were presented in Section 4.2, and a simplified life-cycle assessment is also provided. It is clearly shown that shared micro-mobility offers significantly more advantages than disadvantages, and has the potential to be more sustainable than other modes of transport. Literature also tallies with these as discussed earlier. However, drawbacks related to their shorter lifetime, misuse and improper parking of assets, use of batteries, vandalism, danger and nuisance to other road users, as well as high and regular maintenance costs cannot go unnoticed and still need to be addressed.

Although shared micro-mobility is often regarded as sustainable in literature, findings from the semi-structured interviews and the sustainable assessment highlight the need for a holistic approach to effectively implement these transport modes in Malta. This approach should address all potential drawbacks by promoting the optimal use of shared micro-mobility and ensuring all related aspects – such as production, usage, operations, integration with other modes of transport, regulations and enforcement – are well

coordinated and complimentary. As further discussed in this section, such an integrated strategy will help deliver transport solutions that reduce carbon emissions and energy demand, improve energy efficiency and offer a service that benefits both users and non-users.

5.2. The Requirements for Shared Micro-Mobility Services

The second research question focused on "What are the conditions that are required to sustain a shared micro-mobility service?" As written in Sections 2.1.2 and 2.2.5, the main requirements obtained from literature were discussed. These can be compared to the responses of the second interview question.

As shown in Figure 8, Section 4.1, respondents from the semi-structured interviews highlighted the importance of having a good service that is cheap, safe and convenient. This tallies with the need for a competitive advantage as discussed in literature [28] [62]. However, the need for better enforcement and limitations, such as the wearing of protective gear, restrictions on main roads and pedestrianised areas, speed and age restrictions, were also highlighted.

Another important requirement arising from the semi-structured interviews was the provision and maintenance of safe infrastructure, such as segregated lanes, safe, streamlined and comfortable crossings (such as level-crossings and sub-ways) and cycling networks. This also tallies with Camilleri et al., who recommended to extend the road space allocated for these modes of transport [62]. The provision of such lanes also promotes the competitive advantage of micro-mobility since such modes are able to by-pass traffic [38] [63]. Analysing the recent situation in Malta, interviewees also highlighted the importance of providing allocated parking spaces for these modes of transport and their services, as also noted by Ahmadreza et al. [65], to solve the improper parking issue, their misuse, vandalism and reduce the visual impact of these modes of transport.

As highlighted by Bajada et al., changing people's mind set on shared micro-mobility in Malta remains a long process [66]. A change in mind set and acceptance was also highlighted by participants during the semi-structured interviews. Through educational campaigns and activities, the social perception of shared micro-mobility can be

improved. Political will, amongst local politicians, was also highlighted to see micro-mobility as a solution to local transport problems and commit to long term solutions and projects. By targeting 18-24 age category, providing more information about monetary and time savings and linking towards the promotion of health, such campaigns can prove to be effective as discussed by Maas et al. [6].

Transport management, including the proper implementation of policies and regulations and integration with other modes of transport, were other requirements provided from the semi-structured interviews. The responses tally with literature. In fact, the need for a service to be equitable, non-exploitative and fair through a good regulatory framework was highlighted by Ditta et al. [28]. Integration, especially with public transport, was also highlighted from the local councils interviews by Bajada et al. [66] and such services should not be considered as stand-alone, but fully integrated in the urban landscape [27].

The semi structured interviews highlighted the need for more pilot projects, allowing the space for experimentation prior to launching at national level. The importance of understanding the Maltese market was also highlighted, to adapt to our specific local requirements and culture. Such requirements were not found in literature and only highlighted in the semi-structured interviews.

Better engagement and collaboration amongst stake-holders to form better integration was also highlighted from the interviews which tallies with what Maas et al. said, stating that businesses, governments and society should strive to achieve a common objective for sustainable transport [3]. More financial incentives from the government or the workplace were emphasised, while car disincentives were also highlighted by respondents. Camilleri et al. stated that the car should become the least likely choice for travel [62].

As can be seen, responses by stakeholders from the interviews and from literature, for the requirements needed to implement and sustain shared micro-mobility services, tally. This shows that stakeholders know what is needed. This begs the question as to why, despite knowing, certain requirements were not implemented, or if they were implemented, such as regulations or policy, why such requirements are not as effective as expected.

5.3. The Attributes that led Shared Micro-Mobility Services to leave Malta.

The third research question was "What are the determinants that led to these shared micro-mobility services leaving the islands?" Although in literature there are drawbacks and challenges attributed toward shared micro-mobility services, one begs the question to what degree were those drawbacks in Malta, that eventually led to these services no longer being an option to commuters.

As can be seen in Figure 7, Section 4.1, the main attributes obtained from the semi-structured interviews, why shared micro-mobility services left the islands were due to abuse, chaos and lack of discipline by the users, including bad parking habits and dangers to other road users (as shown in Figure 16, Figure 17 and Figure 18). This was followed by no regulations, policies, legislations or enforcement.

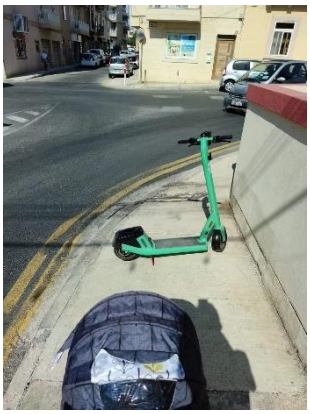

Figure 16 - showing E-scooter blocking the pavement for a pedestrian with a pram *[73]*.

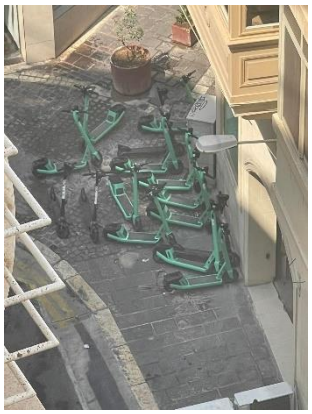

Figure 17 - Several E-scooters left on pavements, completely blocking the pathway *[73]*.

Figure 18 - An image of two children on one scooter speeding in a pedestrianised zone *[72]*.

Other reasons include lack of infrastructure and safety. The negative public perception, and public outcry was another reason given. Other participants replied that the reason they left was because service providers not receiving profits or return on their investments, especially since their assets were being prone to misuse and vandalism. In fact, a service provider confirmed that "the fees are so low but the costs are so high". Others explained that the Maltese population is inactive, they are not used to simply walking and have a culture of owning cars.

Of course, the political decision to ban e-scooter shared services in 2024. Figure 10, Section 4.1, gives an idea of the perception amongst the stakeholders on their opinion of the ban. As can be seen nearly 40% of the participants agreed with the ban, citing how aggravating the situation in Malta was, despite the majority of participants (83%) perceiving shared micro-mobility services as sustainable and a solution to our transport problems in Malta.

The drawbacks of shared micro-mobility services in Malta, listed above, show that several necessary requirements, deemed as necessary in Section 5.2, through literature and the semi-structured interviews, were in fact missing. This suggests that shared micro-mobility was implemented ahead of their time, and Malta was not ready in terms of social acceptance, infrastructure, regulations and resources for enforcement. One participant said that it happened "so abruptly and [they] weren't regulated!" Their popularity and growth amongst users was exponential and in turn, their drawbacks resulted in abuse, chaos and loss of control. Which of course may have led to a drastic decision to ban such services and halt operations.

Although this may appear to be far-fetched or extreme, several stakeholders understood the gravity of the situation, quoting the importance to have a good regulatory framework and provide enforcement. However, one participant said that "Perhaps we have lost an opportunity there, to be able to implement them properly" with another expressing that they will be "difficult to reintroduce them again".

5.4. The Current Position of Shared Micro-Mobility in Malta

The fourth research question was "What is the current local position of transport policy regarding shared micro-mobility?" A policy review of the Transport Master Plan 2025 and the National Transport Strategy 2050 was done in Section 3.3.3.

In the Transport Master Plan 2025, written in 2016, shared micro-mobility services were mentioned in a measure tackling the problem of peak hourly demands of traffic and how incentivises should be provided to encourage commuters to avoid driving their cars during peak periods, through the use of "smaller, more road-space efficient vehicles" including "bicycle use". Furthermore, in the masterplan, it says that e-bike sharing services "are increasingly popularity in towns and cities around Europe" and can provide

"an alternative means of travelling" for working commuters and tourists. E-bike sharing systems were also referred in the Sustainable Urban Mobility Plans (SUMP) for the Valletta Extended Region and the "Gozo Cycle sharing scheme". However, e-scooters were not mentioned in the masterplan.

On the other hand, in the National Transport Strategy 2050, written in 2016, shared micro-mobility services, or shared modes of transport are not mentioned in the strategy document. Only cycling or walking are mentioned as active modes of transport, which are non-inclusive of shared services. These were mentioned as part of a guiding principle towards generating a culture for modal shift.

The limited reference of shared micro-mobility services, particularly e-scooters, which does not feature in any policy that was reviewed, shows that Malta was not ready and had no plans or strategies in place for these innovative modes of transport. Moreover, the policy documents shows that they are outdated for shared micro-mobility services.

However, the government is looking towards the future as explained previously in Section 3.1. Through the formation of the *Reshaping Our Mobility* action plan, the Ministry of Transport is showing some venture in shifting mobility patterns towards more active modes of transport such as the bicycle and e-scooter. Although the attractive measures, the sharing services are still not being mentioned, there is no push to reintroduce shared micro-mobility services back in Malta, and the government's position is to only push for the privatised use of these modes of transport [72].

Although commuters are using their personal micro-modes of transport, one questions whether there are any changes to the regulations or enforcement. One can understand that there is more care given by the commuter towards the use and parking of such private vehicles, and misuse and vandalism is significantly reduced. In fact, in relation to privatised use one participant said that commuters "tend to be more careful when the assets are theirs". They went on to say that people "are more educated and disciplined when they have the personal equipment".

However, there may still be some abuse taking place. In fact, nowadays, it is not rare when one notices an e-scooter rider zooming on the roads, driving on arterial roads or driving wrong way or in the middle of the road. It is also common to see active commuters riding without helmets or protective gear or running through red lights. More so, people are still riding close to pedestrians on pavements and promenades. From the

interviews, regarding e-scooter use one participant said that commuters “think they have a motor and that they own the road; having a motor, they seem to feel more entitled”.

5.5. Recommendations for the Future Position of Shared Micro-Mobility in Malta

The last research question was “What are the recommendations from transport stakeholders for future transport policy to promote shared micro-mobility?” Through the semi-structured interviews, several recommendations were gathered. Recommendations for the future implementation of shared micro-mobility services and sustainable transport in general were obtained as presented in Figure 11 and Figure 12, Section 4.1.

The tree map chart in Figure 11 shows the vast recommendations received from participants regarding shared micro-mobility services. Most recommendations were attributed to integration and the importance of linking, that is making it convenient and easy, such services to public modes of transport, particularly the bus service and ferry services. Another main cohort of recommendations were attributed to the need for a cultural shift in mentality towards the acceptance and support towards persons choosing active modes of transport. This can be done through campaigns, activities, incentives or car disincentives as well as gaining political will.

Regulations and infrastructure recommendations were also highlighted as can be seen in Figure 11. In terms of regulations, policies, regulatory frameworks, all forms of restrictions, licencing and enforcement were mentioned. This tallies with Figure 8, where service requirements such as regulations and enforcement were mentioned the most as the necessary requirements for share micro-mobility services. This should also tackle the “abuse, chaos, no discipline” and “no regulations, policies or legislation” attributes (refer to Figure 7) that participants claimed were the reason why such services were not successful in Malta. Segregated lanes were the most commonly mentioned form of infrastructure required to promote shared micro-mobility use, which should also tackle the “lack of infrastructure” (refer to Figure 7) reason as to why such services left Malta. Moreover, forced parking was also highlighted, with one service operator during the interview stating “for Malta specifically, the solution is mandatory parking zones”.

As seen in Figure 11, recommendations to explore the market were also mentioned, particularly the need for pilot projects and space to experiment to determine business opportunities. One participant gave a summary of how this can be done, particularly the need to determine "how big is the market, if we perceive value in it and if it is possible to do it with a profit". The participant went on to explain that "if any one of these three things are missing, then we are not ready yet", highlighting the fact that Malta may not have been ready when shared micro-mobility services were first introduced. The same participant concluded "perhaps we must identify some other forms of similar concepts, maybe this is not the right one". Finally, technology advances were also mentioned as recommendations to continue advancing the service.

Recommendations for overall sustainable transport in Malta are presented in Figure 12. As can be seen, the majority of recommendations (around 59%) were attributed towards enhancing the public transport, providing mini-bus services and enhancing the maritime transport. This clearly shows that the position of the participants is that such services are lacking potential. Yet again, as highlighted in Figure 12, results show the importance participants give to shared micro-mobility needing to go hand-in-hand and integrated with a good public transport system. Others also reignited the need for a mass transit system such as the metro.

Through literature, recent trends were determined, and second-generation e-scooters with swappable batteries are increasing in popularity, having a carbon footprint 12% lower [56] [57]. Moreover, to further reduce emissions, services are now opting to reduce the frequency of collection of their assets and use fuel-efficient vehicles to do so, enforce the use of solar energy to charge their batteries and limiting the replacing and charging of batteries [58] [54]. This tallies with what a service provider also highlighted during the semi-structured interviews. He went on to explain that as a service, they are subject to audits and improving Key Performance Indicators (KPIs) to constantly build the sustainability of their service.

Chapter 6: Conclusion

This dissertation addressed a hot topic for Malta. Malta faces several transport problems and has a high use of the private car. Shared micro-mobility services, such as bike, e-bike and e-scooter modes, were introduced in 2016 and 2018. Shared micro-mobility services have a sustainability advantage over the private car use as shown in Section 2.2.3, from the literature review. From the semi-structured interviews, 15 out 18 participants confirmed that the perception of these modes of transport is that they are sustainable and offer several benefits, on all aspects of sustainability: the economic, environmental and social pillars.

However, shared micro-mobility services do pose several challenges, as observed in literature. In fact, the situation was so bad that the government of Malta, posed a ban in 2024 on shared e-scooters, while other shared micro-mobility services left the islands. The semi-structured interviews, conducted with 18 experts or stakeholders from the transport sector, show that the situation was in a terrible state with abuse, chaos and no discipline amongst shared micro-mobility users, sparking dangers to other road users and pedestrians, vandalism and misuse of assets.

Through the semi-structured interviews, it is clear that everyone has something to say about shared micro-mobility and all found it easy to provide the necessary requirements, solutions and recommendations. These were gathered to understand what needs to be implemented for the good use of active modes of transport and possibly the reintroduction of shared micro-mobility. Nowadays, the government's stance is to promote shared micro-modes of transport more with the privatised owning of such vehicles. However, from the interviews the following requirements and recommendations were concluded to be the most influential:

1. **Understanding the market** – including pilot projects and activities, in which an understanding of what the particular local requirements, specific to Malta, are and create a space to experiment and learn what is needed to sustain the service, the necessary regulations and enforcement and if all can be done at a profit to be sustainable.
2. **Introduce a regulatory framework and enhance enforcement** – ensure that proper enforcement is in place to eradicate abuse by all road users, including users of micro-mobility (either using a service or their private vehicle).

3. **Enhance a culture of sharing and acceptance** – through campaigns, education and activities, more acceptance and awareness amongst all road users and pedestrians is required, to ensure respect and tolerance to make our roads safer. Additionally, knowledge is key, all road users should be aware of road regulations and should not be exempt from following them.
4. **Enhance mass transport and multimodality** – through the proper integration of micro-mobility with several public transport modes (buses, ferries, minibuses, etc.) and other modes of transport, multimodality is essential to cover longer distances and promote micro-mobility as a "last-mile" concept.
5. **Share the space and infrastructure** – through segregated lanes, networks, mobility hubs and parking, amongst others, to allow users safe commutes while also preventing dangers to other road users.

It is clear that the culture of owning a car is prominent, especially since Malta is so small, has good weather most of the time and commutes are generally short distances. One respondent from the interviews remarked that "with an electric bike it takes [them] 25 minutes to cycle from Birżebbuġa to Mater Dei, 30 minutes from Mġarr to St Julian's, from Valletta to Birkirkara it took me only eight minutes and from Balluta to Valletta, 10 minutes". They remarked that "these are the numbers which people need to be aware of."

One limitation of this study is that it is a case study focused on one situation in Malta. Although, results and analysis are particular to the island, lessons learnt are useful for knowledge transfer to other regions, cities or countries having a similar context to Malta. Another limitation of this study is that the results are obtained from interviews, requiring human interaction. It is a qualitative study, and respondents could have been biased and responded in their particular interest. Although results can be subjective and are subject to interpretation, each remark by participants was duly noted.

5.6. Recommendations for Future Work

Recommendations for future work include an enhanced sustainability assessment to determine the energy consumption, energy efficiency and carbon footprint of e-scooters and e-bikes currently being used in Malta. A second recommendation is to obtain an understanding of the energy sources and energy consumption used by such modes of transport, which will determine if there is any promotion of such modes of transport to be charged using renewable sources of energy. Another recommendation for future work is to perform a study to understand the impacts on pedestrians and other road users pre and post the e-scooters ban in Malta in 2024. An alternative suggestion is to perform a study to analyse and compare the sustainability impacts of shared versus private e-scooters and e-bikes in Malta.

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