# MITIGATING CLIMATE CHANGE THROUGH SUSTAINABLE MOBILITY - A FRAMEWORK FOR DEVELOPING LOW-CARBON TRANSPORT POLICIES

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## Dedication

***To my family***

## Declaration

This is to declare that this thesis is an original and unpublished study carried out by the undersigned and is presented to the University of Malta for the first time as part of the requirements for the award of Doctor of Philosophy.

**Rosalie Camilleri**

## Abstract

Climate change mitigation and reducing greenhouse gas (GHG) emissions have become one of the most important global challenges. Transport is one of the sectors that contribute significantly to GHG emissions. It is one of the few sectors where emissions have continued to grow. Road transport is the largest contributor within the transport sector and further growth in the demand for personal transport is forecasted as the world population continues to grow. Despite the significant contribution of transport, the sector has taken a relatively low profile when it comes to emission reduction. Transition to more sustainable travel is proving to be difficult to achieve, and if the climate change mitigation targets are to be reached, alternative and trend-breaking transport futures are required.

This research adopted a Theory of Social Practice as the conceptual framework for analysis to understand what type of alternative transport policies could lead to a significant reduction in the levels of emissions. To explore these alternatives, a backcasting framework was used which enabled visioning of these alternative and design of pathways to reach them. This framework and the impact of perspectives from the Theory of Social Practice on climate transport policies was tested in a case-study approach. This research was focused on the case of Malta which presents a setting with high population density and a high car-dependency and a case where transition to more sustainable forms of transport has proved to be challenging.

The aim of the research was to analyse how a transition to low-carbon mobility can help to achieve climate change mitigation targets. This aim was reached through a combination of qualitative and quantitative methodological tools which served to i) provide a picture of the current situation in terms of mobility practices; ii) develop alternative transport and more sustainable futures for Malta; iii) test the potential of these futures to limit emissions; iii) design policies which can lead to these futures.

Mobility practices in Malta were found to be dominated by the reliance on the car. These results were further complimented with other findings on the current travel conditions in the case study. Survey data revealed that the demand for travel and travel choices are shaped by the range of activities and daily routines of the inhabitants of the islands. Participation of a range of stakeholders in the visioning of alternative futures provided a space for discussions and brought together different ideas about what a sustainable transport future in Malta would look like. The results of the transport modelling exercise showed how significant emission reduction from transport is challenging and achieving the climate change mitigation targets might need an integrated approach and a mix of alternatives. The results of the research show how designing transport policies using concepts from the Theory of Social Practice can provide a broader range of influence and can help to provide insights into how transport choices can be influenced by interventions in non-transport sectors.

The findings and recommendations of this study contribute to a better understanding of how transport policy making can benefit from social science perspectives and emerging theories, such as the Theory of Social Practice. The results of this research and how the analysis mobility and other everyday social practices could open new possibilities for the transition towards more sustainable transport futures.



***Keywords:*** *transport; climate policy; participatory approaches; social practices; climate change mitigation; backcasting*

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## List of abbreviations

| | |
|---|---|
| ASTRA | Assessment of Transport Strategies |
| BAU | Business As Usual |
| $CO_2$ | Carbon dioxide |
| CAQDAS | Computer Assisted Qualitative Data AnalysiS |
| COP | Conference of Parties |
| EEA | European Environment Agency |
| EU | European Union |
| ForFITS | For Future Inland Transport Systems |
| GHG | Green-House Gas |
| IPCC | Intergovernmental Panel on Climate Change |
| MAAS | Mobility-As-A-Service |
| MARS | Metropolitan Activity Relocation Simulator |
| NDC | Nationally Determined Contributions |
| PCT | Personal Carbon Trading |
| TA | Thematic Analysis |
| TPB | Theory of Planned Behaviour |
| UNECE | United Nations Economic Commission for Europe |
| UK | United Kingdom |
| UNFCCC | United Nations Framework Convention on Climate Change |
| WCED | World Commission on Environment and Development |
| WHO | World Health Organisation |
| BRT | Bus Rapid Transit |

# CHAPTER 1: INTRODUCTION

The urbanised world, and fast paced socio-economic developments have brought with them a challenge for social, economic and environmental sustainability. The urban population has grown rapidly over the years, reaching 7.8 billion by mid-2020, rising from 7 billion in 2010, 6 billion in 1998, and 5 billion in 1986. The average annual growth rate was around 1.1% in 2015–2020. The trend in the world population growth is expected to conthe world population is projected to reach 9.7 billion by 2050 and 10.9 billion by 2100 (Gu et al., 2021). By 2050, 66% of the total global population will reside in urbanised areas (United Nations, 2014). Despite a general trend in population growth, there are variations in the future trends of populations across regions and countries. Overall, more than a half of the global additional projected increase between 2020 and 2050 will occur in countries in sub-Saharan Africa. In contrast, populations in Eastern and South Eastern Asia, Central and Southern Asia, Latin America and the Caribbean, and Europe and Northern America are projected to reach peak population size and to begin to decline before the end of this century (United Nations, 2019).

It is widely recognised that the growth of urban areas has deleterious impacts on both the environmental resources but also on the quality of life and the health of the population. As the demands for the supply of energy, infrastructure, clean water and sanitation increase, so do their negative effects such as poverty, poor air quality and climate change. The challenge therefore lies in finding a balance between meeting the needs of the urban population while at the same not compromising on other aspects of the urban environment – what is termed sustainable development.

The concept of sustainability has different dimensions and looks at aspects of environment, economy and society. While equally important, the environmental dimension of sustainability tends to capture the most attention especially given the direct effect it poses to human health. Within this dimension many aspects are debatable and these include air pollution, water resource management, waste management and climate change. Amongst the environmental issues that have become increasingly pressing with urbanisation and the increasing rates of population growth, climate change is perhaps the most challenging. The concern over global warming and its adverse effects has grown such that climate change has become one of the most discussed issue of the 21st century.

## 1.1 The Research Problem

### 1.1.1 The Concern over Climate Change: a chronology

The climate system consists of the atmosphere, hydrosphere, lithosphere and biosphere which interact together through physical, chemical and biological processes (Pielke, 2008). Climate change is defined as the multi-decadal or longer alteration in one or more physical, chemical and or/biological components of the climate system (Pielke, 2003). Changes in climate are thought to be caused by both natural factors (geophysical activity) and anthropogenic activities (National Research Council and Climate Research Committee, 2005).

A strong debate on which of the causes has the highest contribution to the observed changes exists within the scientific community with some scientists claiming that the observed effects are a result of the natural causes whilst others argue in favour of the increased emissions of Carbon dioxide ($CO_2$) and other greenhouse (GHG) gases which have altered the composition of the atmosphere. Scientific studies, such those carried out by the Intergovernmental Panel on Climate Change (IPCC) indicate that the accumulated $CO_2$ is leading to warmer global surface temperatures (IPCC, 2014a). This rise in temperature, is known to cause increased frequency of extreme weather events such as heightened storm intensity, altered precipitation patterns, sea level rise and reversal of ocean currents which in turn have significant impacts on the functioning of ecosystems, the viability of wildlife and human health (Goulder et al., 2006).

The IPCC, in its Sixth Assessment Report (AR6), has stated that the GHG emissions have continued to accelerate since the start of the industrial time-scale. The report has given evidence how GHG emissions related to anthropogenic activities have continued to increase over the period of 1970 to 2010 with the largest absolute increase occurring between 2000 and 2010 (IPCC, 2022). Projections also indicate a clear linear relationship between cumulative $CO_2$ emissions and global temperature increase (Karl et al., 2003) where more than half of the increase in global average surface temperature has been attributed to cumulative $CO_2$ emissions which have more than doubled since 1970.

The IPCC, established in 1988 under the auspice of the United Nations Environmental Programme and the World Meteorological Organization, is the international body responsible for the assessment of climate change. The goal of this international panel is to group scientists and experts to provide a clear scientific view on the current state of climate change and its potential impacts. The IPCC has produced a series of emission scenarios showing the most probable outcomes based on the current GHG emission trends as part of its Fifth Assessment Report (AR5) which was published in 2014. The report is a comprehensive assessment of climate change, with the input of a significant number of scientists. The scenarios generated have shown how without any mitigation to limit further release of GHG gases, the global mean surface temperature might increase by 3.7° to 4.8°C over the 21st century (IPCC, 2014a). A temperature rise of 3°C or more would have devastating effects that would radically change the earth's systems as we know them today and significantly affect human life. Under these scenarios, the sea levels are projected to be 0.45 to 0.82 metres higher (IPCC, 2014b). The World Health Organisation (WHO) estimates that between 2030 and 2050 there will be approximately 250,000 additional deaths per year from malnutrition, malaria and heat stress because of climate change (World Health Organisation, 2017).

To prevent the most severe impacts of climate change, a 1990 report by the Stockholm Environment Institute recommended to limit the global warming to 1°C as the safest option. At the same time, the report also recognised that such limit may be unachievable and thus suggesting a maximum temperature limit of 2°C (Rijsberman et al., 1990). The findings of the AR5 imply that to achieve this limit, substantial and sustained global reductions of greenhouse gas emissions are required. Furthermore, any delay in emission mitigation pathways is likely to increase the size of emission reductions required in the future. Estimates show that for the temperature change caused by anthropogenic activities to be kept below the 2°C, mitigation measures must aim to limit the atmospheric GHG concentrations to 450ppm of $CO_2$ equivalent by 2100. In achieving such an aim, drastic cuts in GHG emissions must occur by 2050, which emissions need to be reduced by 40% to 70% relative to the 2010 levels (IPCC, 2014b).

Since the publication of the AR5, the international community has started to act to reduce emissions of GHG and hence limit further global warming. Most noticeable in the United Nations Framework Convention on Climate Change (UNFCCC) under which framework governments from over the world meet and put forward agreements to combat the effects of human intervention on the climate system. The Kyoto Protocol (signed in 1997) which was ratified in 2005 and ran till 2020 was the first of a set of agreements made under the UNFCCC. The Kyoto Protocol was then superseded by the Paris Agreement which came into force in 2016.

The Paris agreement, which in the words of the UN Secretary-General was *a monumental triumph for people and our planet*, was reached at the 21st meeting of the Conference of Parties (COP21) of the United Nations Framework Convention on Climate Change, and presents an international binding agreement that aims to bring global GHG emissions under control. In contrast to the previous meetings of the UNFCCC (most popular is the COP3 and the resultant Kyoto Protocol), the Paris Agreement has begun to acknowledge the importance of domestic politics in climate change and allows for the countries to set their own ambitions and goals in terms of climate change mitigation. The key provisions of the agreement focus on a global objective of holding the temperature increase to well below 2°C and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels and an aim of reaching global peaking of emissions as soon as possible (Dimitrov, 2016).

Despite offering a fresh start many observers have labelled the agreement as being "too little too late" and that more needs to be done to avert from the dangerous consequences of global warming. While welcoming the ambition of limiting the global warming to below 2°C and aiming for keeping temperatures below the 1.5°C, many are sceptical that these aims will be reached. Early estimates such as those by the Climate Action Tracker, show that the nationally determined contributions (NDCs) received in the run-up to the COP21, would be insufficient to keep global warming below 2°C and projections point to a rise in the range of 2.6 – 3.1°C above the pre-industrial levels by 2100 (Fawcett et al., 2015; Gütschow et al., 2015; Rogelj et al., 2016). This estimation, which is obviously based on the assumption that all national pledges will be fully implemented, highlights a substantial gap between the global emissions in the NDCs and the 2°C scenario. Others have also pointed out how the voluntary nature of the individual countries' emission reductions can be a major challenge in reaching the aim of the agreement (Vandyck et al., 2016).

While the targets set in the Paris Agreement (adopted in 2015) are still achievable, the implementation of actions that limit further increase in greenhouse gas emissions must be fast since the time window of opportunity for limiting climate warming to 2°C (and even 1.5°) is closing rapidly. Now that the international community has come to the agreement that the emission reduction and climate change mitigation should take place at the national level, developed countries need to take the lead in putting in place drastic measures that will ensure that global warming is kept in check.

When paying attention to the discussions on climate change and the literature dealing with this environmental issue, it becomes evident how the climate change debate has been framed by a science perspective. Strong scientific data on the degree of global warming and other climatic changes together with analysis and projections of the levels of GHGs have been formalised and presented.

The economic impacts of climate change have also been emphasised and together with the scientific background used to influence policy formulation and decision making. However, the social science perspective seems to be lacking from the themes of the evolving challenges of climate change (Yearley, 2009).

The lack of contribution of the social sciences has important consequences especially since, as Dennis and Urry (2009) remark, *the nature of social life is central to the causes, consequences and possible mitigations involved in global heating.* Understanding the nature of social life could highlight pathways on how changes can be made to reduce carbon-intensive activities in cities. One aspect of this social life that merits attention due to its contribution to GHG emissions is mobility. As it will be highlighted in the following section, as a significant contributor to emissions, transport plays a critical role in climate change mitigation.

### 1.1.2 Transport and Climate Change

Transport has been an important factor in the development of the post-industrial years. The fast movement of people and goods over long distances, at increasing speeds, and at affordable prices has enabled significant economic growth during the last decades. Despite the benefits of such patterns of mobility, transport also has several negative impacts on the environment. Transport is a primary source of energy-related GHG emissions, which gases are known to have effects on climate change. Transport accounts for 23% of the total $CO_2$ emissions and 61% of the global oil consumption (International Energy Agency, 2021a).

The problem however is that, as Ryley and Chapman (2012) point out, transport is one of the few sectors where emissions have continued to grow. It is the second fastest growing source of GHG emissions and it is forecasted that by 2050, there will be further growth in emissions (Gleave, 2000). This growth is the result of the increasing demand for mobility. It is estimated that the total distance travelled by the world population will increase from 23 billion km per year (as projected for 2009) to 104 billion km by 2050 (Schäfer et al., 2009). Increased mobility patterns become an issue for climate change when mobility takes place through motorised forms of transport as this results in the emissions of $CO_2$ (in addition to other pollutants). Road transport is the largest contributor to $CO_2$ emissions within the transport sector accounting for nearly 73% of the total transport $CO_2$ emissions world-wide (International Energy Agency, 2021b).

In the European Union, the total GHG emissions were observed to decrease in recent years and in 2019, the levels of emissions were 24% below 1990 levels, and estimated 31% less (than the 1990 levels) in 2020 (European Environment Agency, 2021b). Most of the sectors in the EU reduced their emission contribution. For example, the total emissions from the energy sector fell by about 43% since 2005. Contrastingly, the emissions from transport in the EU continued to grow both for passenger and freight transport, in spite of climate policies and the deployment of less carbon intensive and more efficient vehicles on the market. Up till 2019, the increasing transport demand could not be outweighed by the increasing efficiency of vehicles, and as a result, transport emissions in 2019 closely resembled those observed in 2005 (European Environment Agency, 2020). Road transport constitutes the highest proportion of overall transport emissions and it accounts for 72% of all domestic and international transport GHG (in 2019) (European Environment Agency, 2021a).

Despite the significant contribution of transport to the global levels of $CO_2$, transport has been overlooked in its contribution to carbon reduction targets. Transport is a key sector to reduced GHG emissions and limit the average effects of global warming. However, decarbonising the transport sector has been proved to be a difficult task despite advances in low-carbon technology and measures set both at national and international levels (Skinner et al., 2010). It may be argued that the difficulty in cutting emissions from the transport sector is two-fold. On one hand, it is commonly perceived amongst policy makers that given the importance of transport in facilitating accessibility and global trade coupled with the dependence of the sector on oil, reductions in transport are difficult to pursue (Loo et al., 2016). Another major barrier to the reduction of emissions from transport is the rise of *automobility* and the dependence of personal mobility on the car (Urry, 2007).

Transport, one of the most important socio-technical systems of the modern society, has locked into it forms of mobility which are dependent on the use of fossil fuels. In the context of climate change mitigation and emission reduction, the challenge is thus to escape from such path-dependant fuel-based energy systems. The challenge cannot be dealt with only at a global scale. Individual countries must take responsibility in devising plans on how to control emissions from the sector if the climate target of 2°C is to be met.

### 1.1.3 Sustainable mobility: an opportunity to reduced $CO_2$ emissions

The current situation in the transport sector is unarguably not sustainable, in environmental and indeed social terms. Transport must contribute fully to achieving carbon reduction targets and alternatives that deliver more sustainable forms of transport are required if the climate change mitigation targets are to be achieved.

The idea of sustainable mobility is not a new concept and it emerged in 1992 EC Green Paper on the Impact of Transport on the Environment (European Commission, 1992). This paper followed from the discussions of the global challenges of sustainable development (World Commission on Environment and Development (WCED), 1987) and was the European Union's response to the concerns raised over sustainable development issues. The focus of this response were the issues of environmental protection, safety and security, consumer protection, labour rights and social policy, and the external costs of transport. While the EU recognized the importance of the effects of transport on the environment, there was no mention of climate change, which at the time was still not one of the major global issues.

Sustainable transport is defined as the means of achieving a level of physical mobility that meets the basic mobility needs of the society, ensuring social justice in a manner that limits environment degradation and GHG emissions to a level that is consistent with international efforts towards sustainable development (Bardal et al., 2020; Griffiths et al., 2021; Holden et al., 2020). European Conference of Ministers of Transport's (ECMT) gives a broader definition of sustainable transport which identifies a set of key issues for sustainability. In this definition, a sustainable transport system:

i) allows the basic access and development needs of society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.
ii) is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development.

iii) limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation and uses non-renewable resources at or below the rates of development of renewable substitutes while minimising the impact on the use of land and the generation of noise (European Conference of Ministers of Transportation, 2004)

Sustainable mobility provides an alternative paradigm to the conventional approach of transport planning. Within this new paradigm, actions are focused to reduce the need to travel (less trips), to encourage modal shift, to reduce trip lengths and to encourage greater efficiency in the transport system (Banister, 2008).

The sustainable mobility paradigm suggests that transport can contribute to sustainable development through four differentiated actions. First, reducing the need to travel by replacing a trip by either a non-travel activity or substituted by the engagement of ICT (e.g. teleconferencing) (Lyons et al., 2003). Modal shift away from car-cantered modes of mobility to active forms such as walking and cycling characterizes another set of actions that can contribute to sustainable mobility. Policy measures that can contribute towards modal shift include the provision of infrastructure that enable use of alternative modes. Measures that are aimed at deterring car use whilst making other forms more attractive can also contribute to more sustainable forms of travel (Ferretto et al., 2021). Reduction of the distance between different sites of activities can contribute to less need for travel, hence more sustainable mobility. This can be achieved by switching to green modes of transport and by applying policies which focus on developments with increasing densities and concentration of housing, the design of buildings, public spaces and transport routes that give emphasise on car-free developments. Technology is also a contributor to achieving sustainable mobility. The use of the best available technology in terms of car engine design, alternative fuels, and use of renewable energy together with behavioural change can lessen the negative impacts of transport (Banister, 2008).

Another approach to transport planning, which is similar to the sustainable mobility paradigm and which also aims at achieving sustainable mobility is the avoid-shift-improve nexus. The strategy is based on looking at ways to avoid travel through shorter journeys and more accessible activities, to shift travel to public transport rather than the car, and to improve the efficiency of all forms of transport. This alternative approach to the predict and provide method for transport planning is aimed at meeting key performance goals for the transport system and at the same time meeting emission reduction targets and climate change mitigation objectives. The approach is intended to guide transport policies to address the challenges of urban transport especially with regard to emissions from the sector.

Diminishing travel demand and thus avoiding some trips is one way of reducing the negative effects of transport. This can be achieved through telecommunication, online shopping and improving the local access to jobs, goods and services. Design of dense urban environments also helps reducing the need for travel by car and improves accessibility by other modes such as walking or cycling (Banister, 2011). Shifting travel to more efficient or clean forms such as non-motorized transport or public transport is another strategy that can help promote sustainable transport. The most promising among all these measures especially in urban areas are mass urban transit projects like metro and bus rapid transit (BRT), which not only increases the efficiency of transporting passengers but also has significant sustainable development co-benefits, such as reducing air pollution and congestion (Nakamura et al., 2013). Improving the efficiency of the transport system, such as through the replacement of conventional fuels with cleaner fuels, or switching to electrically operated vehicles can drastically reduce emissions per kilometre of vehicles thus contributing to more sustainable forms of travel (Newman, 2016).

This context provides the problem statement for this study: that transport $CO_2$ emissions need to reduce more significantly, but that this will involve societal changes as well as infrastructural and individual attitudes. Reducing transport $CO_2$ emissions is probably much more difficult than we imagine, particularly in a car dependent context such as Malta. People are used to using cars for travel and they are deeply embedded in everyday lives. A wide-ranging debate is required to examine the possible options, and using participatory scenario analysis offers a way forward for transport planning and public policy.

The next section will describe the aims of this study in the context of the research problem presented in this section. It will summarise the objectives of the research and how these will contribute to meet the aim.

## 1.2 Research Aim and Objectives

It has already been emphasised how significant reductions in GHG emissions are needed if ambitious target of limiting the global temperature rise to 2°C is to be achieved. Transport is one of the major contributors to GHG emissions and thus has an important role to play in climate change mitigation. Resting on these premises, this research seeks to analyse possibilities of $CO_2$ emission reduction from the transport sector. The aim of the research is to analyse how a transition to low-carbon mobility can help to achieve climate change mitigation targets.

The transport sector encompasses within it various modes of activities, from road transport, to aviation and maritime forms of movement. Road transport remains the largest contributor within the sector, with a high potential for significant emission reduction. Aviation is also an important contributor to $CO_2$ emissions. However, analysing transitions in the aviation sector proves to be more challenging, most importantly because of the apportioning of emissions during international flights. Hence, despite acknowledging the contribution of aviation to climate change effects and the need to decrease emissions from this type of transport, this study's focus will be road transport. Within the broad research aim, three research objectives can be defined as summarised in Table 1.1.

**Table 1.1: Research Objectives**

| Objectives | |
|---|---|
| 1 | To identify the key approaches in transport research analysing climate change mitigation and frame a suitable approach for this study |
| 2 | To understand the current transport $CO_2$ emissions and transport trends, and identify more sustainable alternatives. |
| 3 | To determine the likely impacts of the more sustainable alternatives and identify policy pathways needed to achieve them |

## 1.3 The context of the study: Case study selection

Planning for sustainable urban mobility has become an international priority and it is one key area in sustainable development plans which include the Sustainable Development Goals (United Nations, 2015) and the New Urban Agenda (United Nations, 2016). Promotion of sustainable mobility is one of the priorities of the European transport policy. For example, the

EU white paper on transport outlines a number of very ambitious targets, such as the 60% reduction in greenhouse gas emissions by 2050 (European Commission, 2011b).

Many countries have started to incorporate sustainable mobility targets into their transport planning policies and plans. This is reflected in the substantial body of literature that has looked at methods and pathways for moving towards sustainable mobility. These studies have explored different theoretical frameworks and methodological approaches for dealing with the issue of sustainable mobility. A significant number of studies have focused on analyzing sustainable transport in Europe  (Nikulina et al., 2019), with the largest number of these being based in the UK ((Acquaye et al., 2012; Anderson et al., 2005; Anderson et al., 2008; Brand et al., 2012; Hickman et al., 2009; Hickman et al., 2012; Magdolen et al., 2021; Nykvist et al., 2008), Sweden (Åkerman et al., 2006; Börjesson et al., 2012; Loukopoulos et al., 2005; Nykvist et al., 2008; Steen et al., 1999), Spain (Bueno, 2012; González-Eguino, 2011; Julio Soria-Lara et al., 2018) and Germany (Auvinen et al., 2016; Pucher et al., 2008c; Schmid et al., 2012; Zimmermann et al., 2012a). On the other hand, research on transition to sustainable transport in small islands remains very limited (Attard, 2005; Enoch, 2003; Enoch et al., 2008; Soomauroo et al., 2020).

In this research, the Maltese Islands have been selected for investigation, and they represent a context of high dependence on the private car and with specific characteristics of small islands that require tailor-made approaches to transport planning and low-carbon mobility practices.The Maltese Islands consist of three major islands, Malta, Gozo and Comino and a number of smaller uninhabited islands. Malta is the largest of the three islands covering an area of 246km$^2$ (of the total 316km$^2$). The islands are geographically located in the middle of the Mediterranean 93km south of Sicily and 288km north of Libya. The small size of the island state and its isolation from mainland Europe create unique situations that cannot be matched with those in other larger countries.

Small island states have unique economic, social, geographical and climatic characteristics. This uniqueness is the result of the small geographic size, remoteness and isolation and economic dependence from external sources. Their limited natural resources, limited production capacity, remoteness and isolation makes planning and management of sustainability on small islands more challenging than other contexts (Calado et al., 2007). Small islands are also vulnerable to global environmental challenges, in particular climate change. Sea-level rise is one major threat to islands' long-term sustainability. This vulnerability means that climate change is an important environmental issue for small islands and motivates them to act towards emission reduction. Small islands have long been active in voicing their concern over the impacts of climate change and have taken a leading role in advocating climate change mitigation over time (de Águeda Corneloup et al., 2014; Ourbak et al., 2018).

Despite some challenges, the remoteness and isolation of small islands provide them with an opportunity to transition faster to sustainable transport in comparison to other larger states. Their small size and confined space make small islands excellent laboratories for studying transitions to sustainable transport (Soomauroo et al., 2020). While their contribution to global climate change mitigation may be very small (Climate Change Secretariat (UNFCCC), 2005), small islands can still make significant contribution to climate change mitigation by providing examples of transition pathways towards low-carbon transport.

The next sections will highlight the importance of climate change mitigation for the island state and the obligations that Malta has in view of the climate change mitigation targets. It will also give an overview of the transport system in Malta and the contributions of this sector to the $CO_2$ emissions.

### 1.3.1 The importance of Climate Change mitigation

Effects of climate change have already been observed in the Maltese Islands. Amongst others, these included changes in the patterns of rainfall, an increase in the number of days with thunderstorms per year, decreasing mean annual cloud cover and variations in the amounts of bright sunshine (Malta Resources Authority, 2014). Estimates of future effects have been also are presented in Table 1.2. Changes will impact temperatures, precipitation and mean sea level (Malta Resources Authority, 2014).

**Table 1.2: Estimated climate change effects for Malta.**

| Climate Change Effect | Year | | | |
|---|---|---|---|---|
| | 2025 | 2050 | 2075 | 2100 |
| Increase in regional mean temperature | 1.1°C | 2.0°C | 2.6°C | 2.8°C |
| Change in regional mean precipitation | -2.4% | -4.4% | -3.7% | -1.8% |
| Increase in global mean sea level rise | 7cm | 14cm | 23cm | 30cm |

*Source:Malta Resources Authority (2014).*

Climatic events such as the ones which have been observed and the projected changes in the future climate have serious implications. Malta is uniquely vulnerable to climate change because of its geography and socio-economic characteristics. Climate change would bring with it a number of negative impacts particularly on the economy, health, agriculture, land use, migration, tourism and water resources (Malta Resources Authority, 2014). Further to the overall impacts, the effects of sea level rise resulting from climate change would severely affect the transport infrastructure which would in turn have important economic implications on employment, product or service growth/decline, capital investment, competitiveness and skills/educational development and upgrade (Attard, 2015).

### 1.3.2 Malta's Climate Change Mitigation Targets

***The Kyoto Commitment***

Malta ratified the Kyoto Protocol in 2005. At the time, the islands were listed as a non-Annex I party to the agreement meaning that as a developing country Malta had no binding obligations to limit or reduce its GHG levels. Later, during COP15, a request from the Government of Malta was made for the country to be included in Annex I of the UNFCCC, which request was accepted and adopted in 2010. The accession to the convention was conditional, meaning that no quantified emission limitation or reduction targets were taken for the first period of the Kyoto Protocol. This condition signified that Malta was not subject to an economy-wide greenhouse gas related emission reduction obligations until 2012.

This change in status showed the intention of the country to step up its level of activity under the international climate change initiatives. Despite that, under the obligations of the Kyoto Protocol there were no definite emission reduction targets for Malta, however the signing of the international agreement brought with it a number of commitments. These included reporting of the national emissions and formalisation of the mitigation and adaptation strategies to combat climate change and limit the adverse effects of global warming.

***European Union Targets***

Joining the European Union in 2004 meant the adoption of new climate change mitigation targets for Malta. In 2009, the EU developed the 2020 climate and energy package which is a set of binding legislations to ensure that the climate change targets (-20% by 2020 under the Kyoto Protocol) are met. The package sets three key targets namely a 20% cut in GHG emissions (relative to the 1990 levels), 20% of energy from renewables and 20% improvement in energy efficiency. While these packages were aimed to reduce emissions, they are all very low and unambitious targets which are unlikely to contribute significantly to climate change mitigation.

The Effort Sharing Decision (European Commission, 2009b), which was formulated as part of the 2020 climate and energy package, established binding annual GHG emission targets for member states for the period between 2013 and 2020. The targets were aimed at non-ETS sectors which amongst others included transport (with the exception of aviation and international maritime shipping) and were expressed as percentage changes from 2005 levels. The emission reduction targets for Malta under this decision allowed a 5% increase of GHG emissions relative to the 2005 levels. Annual emission allocations for each year from 2013 to 2020, also part of the effort sharing decision, bind each of the member states to regulate their emissions to 2020 in a linear manner. The decision also came with a requirement for monitoring and compliance that ensured corrective actions would be taken in time to meet the annual targets.

In 2014 and as part of its commitment to the Paris agreement, the EU adopted the 2030 climate and energy framework (European Commission, 2014) which aims to cut the GHG emission to 40% (relative to the 1990 levels). The targets which will be delivered collectively by the EU consist of 40% and 30% reductions in the ETS and non-ETS sectors respectively. These are set with the aim of allowing the EU to move towards a low-carbon economy set by the Paris Agreement on climate change while at the same time remaining competitive. Under the 2030 climate energy framework, Malta is bound by a 19% reduction in GHG emissions for non-ETS sectors for the period 2021-2030 (European Commission, 2014).

The EU legislation under the 2020 climate and energy package and the mitigation targets set for 2030, are also in line with the EU Energy Roadmap 2050 that aims to achieve a 80% cut in emissions (relative to the 1990 levels). With this aim, it is recognised that efforts in all of the economic sectors are required to reach this ambitious target. A further policy package, that is the Transport White Paper (European Commission, 2011b), ties in with the roadmap for 2050 and sets out two targets for the transport sector, namely a 20% reduction (from the 2008 levels) by 2030 and a 60% reduction (from the 1990 levels) by 2050.

***The Paris Agreement***

Malta ratified the Paris Agreement on the 5$^{th}$ October 2016, being among the first of the EU member states. The Paris Agreement, which aims to hold the increase in global temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, took effect from 2020. Malta's Nationally Determined Contributions (NDCs) are part of the EU's joint target under the EU Energy and Climate Package, which aims to reduce emissions by 40% from all sectors by 2030.

***IPCC Guidelines***

The IPCC in its assessment report makes recommendations on the required cut in emissions to maintain the temperature increase below 2°C. Based on emission scenarios, the IPCC emphasises that drastic $CO_2$ emission in the range of 25 – 45% (relative to the 1990 levels) by 2020 and between 80 – 95 % by 2050 should be made by industrialised countries. These recommendations are based on the IPCC's scenarios with this target set for the lowest stabilisation scenario (445 – 535 ppm $CO_2$ equivalent). This target has been adopted by the European Council and feature in the climate action plans of a number of EU member states such as the UK and Germany. Malta, despite being an industrialised country has not yet adopted such stringent climate emissions targets and has so far relied on the share of emission reductions under the collective EU target.

A summary of Malta's commitments to international climate change mitigation objectives is provided in Table 1.3. This summary shows the lack of an integrated and strategic policy approach to climate change mitigation in Malta with unambitious targets for emission reductions. The emission reduction targets for Malta, for example reducing emissions by 19% relative to the 2005 levels, are very weak. These unambitious targets mean there is no need for any real policy innovation and significant changes from the business-as-usual situation. With this approach to climate change mitigation, no significant changes in emissions can be expected.

**Table 1.3: Climate Change Mitigation Targets for Malta**

| *Framework / Commitment* | *Target* | *Target Year* |
|---|---|---|
| **Collective EU Targets** | | |
| EU 2020 Climate and Energy Package | 20% reduction in GHG emissions | 2020 |
| | 20% energy from renewables | |
| | 20% improvement in energy efficiency | |
| EU 2030 Climate and Energy Framework | 30% reduction in non-ETS sectors | 2030 |
| EU Energy Roadmap 2050 | 80% reduction in emissions relative to the 1990 levels | 2050 |
| Transport White Paper | 20% reduction from the 2008 levels | 2030 |
| | 60% reduction from the 1990 levels | 2050 |
| **Specific Targets for Malta** | | |
| Kyoto Protocol / Paris Agreement | Reporting of National emissions | On going |
| | Formalise mitigation and adaptation strategies | |
| EU Effort Sharing Decision | 5 % increase in GHG emissions relative to 2005 levels | 2013 – 2020 |
| EU 2030 Climate and Energy Framework | 19% reduction in GHG emissions for non-ETS sectors relative to 2005 levels | 2021 – 2030 |

*Source: compiled by author from European Commission (2009a, 2009c, 2011b, 2014); United Nations (1998)*

### *National Legislation on Climate Change Mitigation*

Apart from the international legislation governing climate change mitigation, there are the national legal frameworks that guide climate change mitigation in the Maltese Islands. In 2015, Malta's Climate Action Act (Government of Malta, 2015) was established with the aim of mitigating climate change by limiting anthropogenic emissions of greenhouse gases and protecting and enhancing greenhouse sinks and reservoirs. In addition, the Act also focused on the reduction of vulnerability, enhancement of resilience and adaptation to the adverse effects of climate change. The national legislative framework on climate change mitigation however does not set targets for emissions reductions. The Act refers to the international treaties and the obligations and commitments towards emission reduction as a Member State of the European Union. In 2017, Malta's Low Carbon Development Strategy was launched and later published in 2021 (Ministry for the Environment Climate Change and Planning, 2021). The aim of this strategy is to allow for the development of visions and action plans up to the year 2050 to achieve the climate change mitigation targets.

In meeting its aim, the strategy outlines a set of measures in seven different sectors, namely; Energy, Transport, Buildings, Industry, Waste, Water and Agriculture and land use, land use change and forestry (LULUCF). The strategy recognises the important role that the transport sector plays in its contribution to GHG emissions generated and the potential the sector has for emission reduction. In its aim to reduce emission from the sector, the document proposes a series of measures to make a shift from private car use to other forms of transport and measures that would support the transition to electric vehicles (Ministry for the Environment Climate Change and Planning, 2021). While presenting a set of measures to decrease $CO_2$ emissions, the Low Carbon Development Strategy for Malta does not provide the tools or ambition to meet the climate change mitigation targets. Even the European Commission has criticised the strategy particularly for the unexploited emission reduction potential in the transport sector and for its lack of agreement with the strategy to fulfil the European Union and Member States' commitments under the Paris Agreement (European Commission, 2020a).

### 1.4.3 Emissions from transport

A time-series analysis of the emission inventory for Malta clearly shows an overall increase in emissions between the 1990 up to the year 2012 (Figure 1.1). In fact, between 1990 and 2012, the change in gross GHG emissions was of 50.6% with the main contributor to the total emissions being $CO_2$ (Malta Resources Authority, 2020).

Following this increase, there was a rapid general decrease up to the year 2016. The total emissions increased again between 2017 and 2018. The Energy sector is the highest overall contributor to greenhouse gas emissions, which in turn is strongly dependent on the emissions from energy generation and transport categories. This sector generates 79% of the emissions. Both the energy generation and the transport categories contributed towards the increase up to the year 2012. The observed rapid decrease in emissions after the year 2012 was the result of an investment in new generation capacity, fuel switching, and alternative sourcing of electricity.

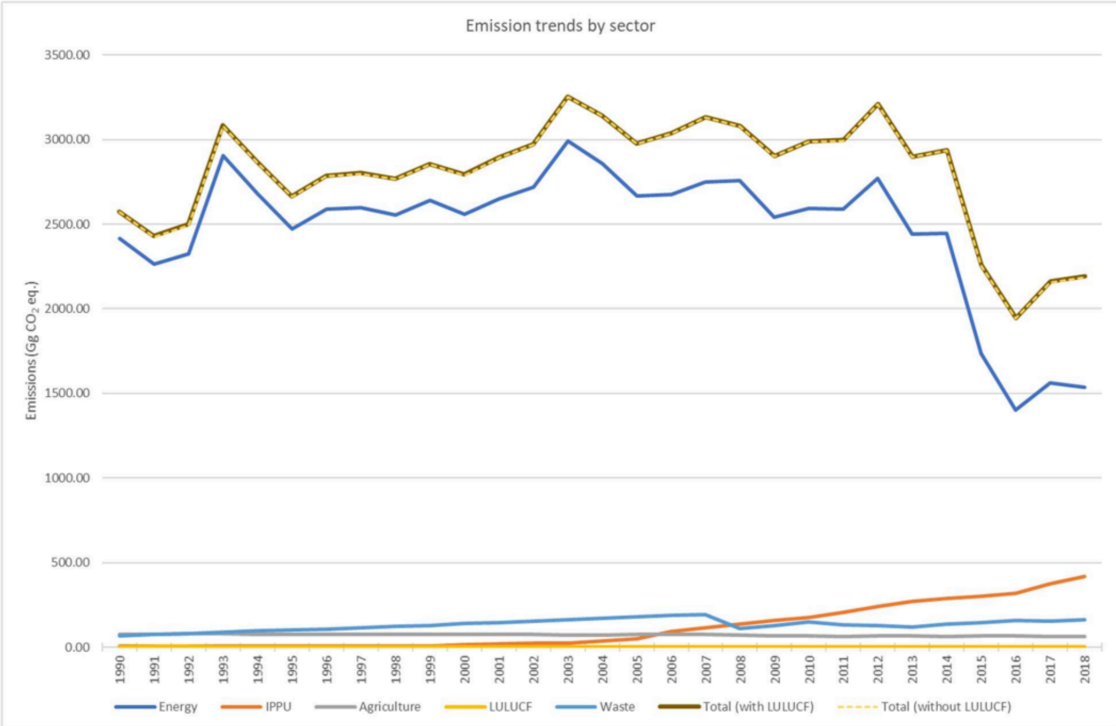



**Figure 1.1: Emissions of Greenhouse gases**
*Source: Malta Resources Authority (2020)*

Transport is a significant contributor to the national emissions. Table 1.4 shows the emissions from transport sector with reference to the total emissions. Transport alone to 35% of the national emissions (Malta Resources Authority, 2020).

**Table 1.4: Sectoral GHG Emissions for 2018**

| Sector | GHG Emissions (kt$CO_2$ eq.) | Sectoral Emissions (%) |
|---|---|---|
| Total (without LULUCF) | 2190.45 | |
| Total (with LULUCF) | 2186.11 | |
| Total Energy | 1525.50 | 69.6 |
| Transport | 651.74 | 29.7 |
| Road Transport | 558.73 | 25.5 |

*Source: Malta Resources Authority (2020)*

The emissions from the transport source category are dominated by emissions from road transport, adding up to 87% of the sector's emissions. $CO_2$ accounts for the bulk of the total GHG emissions from road transport. The share of $CO_2$ emissions from road transport accounts for around 25% of the emissions from all sectors (Malta Resources Authority, 2020). This makes the sub-sector a key source of GHG emission. Trends in the emissions from the transport sector also show a general increase from the 1990 (Figure 1.2).

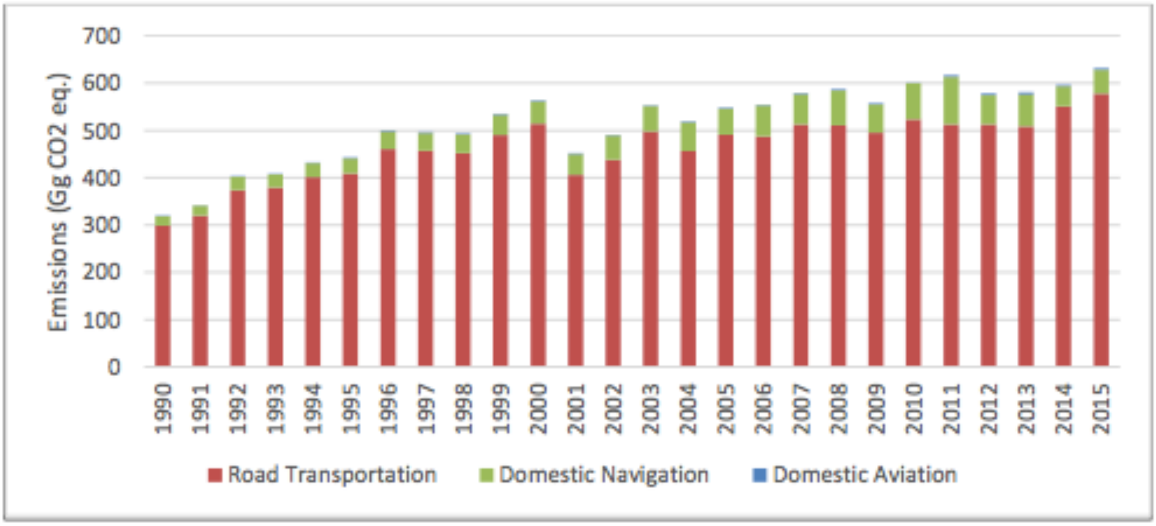



**Figure 1.2: Emission Trends on Transport Sector by sub category.**
*Source: Malta Resources Authority (2017)*

### 1.4.4 GHG emission trends vis-à-vis emission targets

Malta, being a member state of the European Union, has the obligation to meet the emission targets set by the EU. Two emission reduction targets are important in the context of Malta. First, under the effort-sharing decision legislation Malta is allowed to increase its non-ETS emissions by 5% by 2020, compared with 2005 for the period covering 2013-2020 (European Commission, 2009c). Further to this, the effort-sharing obligation commits Malta to reduce its emissions by 19% over the 2005 levels for the period 2021-2030 (European Commission, 2018). The EU emission reduction targets for Malta are too weak and much more needs to be done relative to IPCC global aspirations. A recent study has shown that to have high chances of staying below +1.5 °C global temperature increase, the average per-capita emissions should be 1.9 $tCO_2e$ between now and 2050 (Chancel, 2022). The annual per capita emissions for Malta stood at 5.3 $tCO_2e$ in 2019 (Eurostat, 2022), further emphasising the need for deeper cuts in transport CO2 emissions.

Trends in the GHG emissions for Malta showed that for the period 2013 to 2019, the country's non-ETS emissions were above the emission allocation as defined under the Effort Sharing Regulation (ESR) (European Parliamentary Research Service, 2021). This resulted in a cumulative difference of 1.2Mt of $CO_2$ equivalent over the period 2013-2020 as shown in

Figure 1.3. Projections show that emissions in the effort sharing sectors are still set to increase for the period between 2021 to 2030. These projections strongly indicate that overall Malta is set to substantially miss its 2030 target of -19% reduction of emissions. With existing measures, growths in emissions are estimated to reach 47% by 2030 relative to the 2005 levels (2005 1.12 Mt $CO_2$ eq, increasing by to 1.64 Mt $CO_2$ eq. in 2030) (European Commission, 2020a). According to the Maltese government, the difficulty in meeting the mitigation targets were attributed to the limited mitigation potential and high mitigation costs (Ministry for the Environment Climate Change and Planning, 2021). Malta intends to comply with the annual targets by making use of the ESR's flexibility options, including the transfer of allowances between Member States[1].

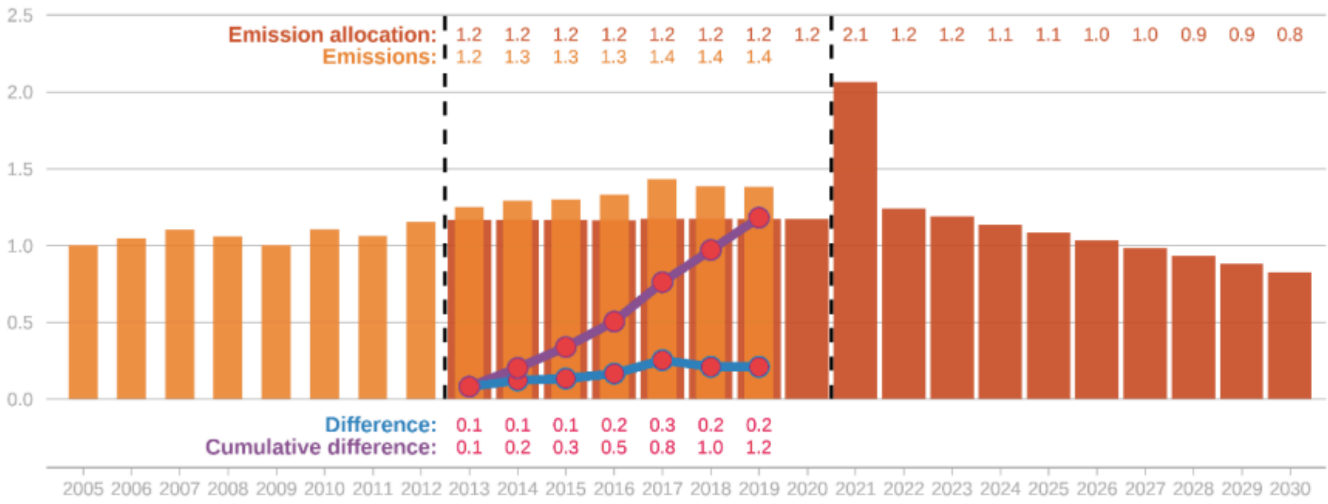



**Figure 1.3: Emissions and EU GHG targets for Malta**
*Source: European Parliamentary Research Service (2021)*

Malta's failure to meet the binding greenhouse gas emissions have been often attributed primarily to a continued increase in transport emissions (European Commission, 2017b; European Parliamentary Research Service, 2021). The transport sector remains by far the highest GHG emissions among non-ETS sectors, with road transport being heavily dependent on private cars where in 2017 for 38.97% of all $CO_2$ emissions.

*[1] The Effort Sharing Regulation allows nine Member States (including Malta) the choice to use a limited amount of Emission Trading System (ETS) allowances for offsetting emissions in the effort sharing sectors in 2021 to 2030. The EU's Emissions Trading System is the largest greenhouse gas emissions trading scheme in the world, Member states must monitor and report their CO2 emissions, and emissions exceed the country's allowances, then a Member State can purchase allowances from others. If a Member State has not reached its emission allowance. In 2015 Malta has purchased 135,000 credits from other member states to apply for this mechanism..*

The National Energy and Climate Plan (NECP) for Malta acknowledges the emission trends and projections in view of the country's obligation to meet its targets and the important role that transport plays in reaching these emission levels. The plan sets out a number of policies and measures intended to reach the emission reduction objectives. These measures include policies that target the transport sector. Measures which support electromobility, public transport, car sharing and other means of transport, such as cycling are amongst those outlined in the NECP. However, the Commission's assessment of Malta's NECP states that the document still lacks ambition, even considering the country's limited mitigation potential and high mitigation costs (European Commission, 2020a). Evidently, a more ambitious plan and more radical policies are required if Malta is to further reduce its emissions and meet the obligations of the climate change mitigation targets. In this context, and as the European Commission (2020) notes, the transport sector has the potential of contributing more significantly towards emission reduction and the attainment of Malta's targets.

### 1.4.5 The State of Transport in Malta

***Motor Vehicle Use***

Malta experienced a rapid rate of growth in motor vehicle ownership and use during the 20th century particularly during the last decade. This was due to rapid economic development which brought about an improved standard of living and allowed greater expenditure on transport which in turn, sustained the growth in car ownership (Table 1.5).

**Table 1.5: Vehicle use in Malta**

| | 1990 | 1995 | 2000 | 2005 | 2010 | 2015 | 2019 |
|---|---|---|---|---|---|---|---|
| **Passenger Cars per 1000 Inhabitants (thousands)** | 337 | 480 | 483 | 525 | 581 | 611 | 597 |
| **Stock of Passenger cars (thousands)** | 120 | 181 | 189 | 213 | 241 | 275 | 307 |
| **Passenger Kilometres (Billion pkm)** | - | 1.7 | 1.8 | 2.0 | 2.2 | 2.5 | 2.7 |

Source: *European Union (2021)*

The increase in car ownership in Malta was also reflected in a shift to private car use where modal share for this type of transport rose from around 55 % in 1989 to around 83% in 2013 and 84.3 % in 2021 (European Union, 2014; National Statistics Office, 2021; Transport Malta, 2010). Various estimates for the annual mileage per vehicle have been reported (Table 1.6), which although not directly comparable (given different methodologies applied), indicate that the demand for private transport is still on the increase.

**Table 1.6: Estimates of Annual Mileage per vehicle**

| Year | 2006 | 2008 | 2012 |
|---|---|---|---|
| Annual Mileage per vehicle (km/yr) | 3,750 | 5,200 | 7,800 |
| *Source* | EC, 2006 | Enoch and Warren, 2008 | ICCSD, 2015 |

***Road Infrastructure***

The road infrastructure in Malta is made up of an extensive 2,400 kilometres of dense network (762km/100km$^2$ of land) (Transport Malta, 2016). The network system is mainly radial, with roads emanating from the capital, Valletta. This radial system is coupled with a number of cross connecting roads between towns and villages (Attard, 2005; Warren and Enoch, 2010).

The development of the road network was largely influenced by the growing demand for transport and growth in vehicle use. The "predict and provide" approach to transport planning was adopted and large infrastructural projects were commissioned in the 1980s and 1990s. This approach was not tied with land use planning and because of the loose transport policies and lack of integrated planning, car use has been relatively unconstrained. The two-party political system has often proved to contribute to reluctance on part of the government to curb car use for fear of upsetting motorist and loosing political trust. Coupled with this, the social element and view of the high status of car ownership have continued to fuel car use (Attard, 2005; Warren and Enoch, 2010).

***Legislative and policy framework for transport***

Transport in Malta is regulated by several laws and regulations. Of most relevance are the main planning documents namely the Strategic Plan for Environment and Development and the Local Plans. These documents contain the framework for urban and spatial planning. Other regulations and guidelines pertaining to transport include those related to road safety, cycling strategy and guidelines for micromobility. A summary of the regulations and policies relevant to transport in Malta is provided in Table 1.7.

**Table 1.7: Legislative and policy framework for transport in Malta**

| Legislation/ Guidelines | Year | Relevance to transport in Malta |
|---|---|---|
| Structure Plan | 1992 | - Identifies the unsustainable growth of private cars and make recommendations for investment in mass public transport and active mobility. It was superseded by the Strategic Plan for Environment and Development. |
| National Strategy for the Introduction of Electro mobility in Malta and Gozo | 2012 | - Promotes electrification of transport as part of national transport policy and as a contribution to achieving Malta's energy and environment targets.<br><br>- Aims to achieve 5,000 EVs on the road by 2020; 500 public charging points by 2020; 10% of transport fuels from renewable sources by 2020; total phasing out of ICE vehicles by 2050. |
| Road Safety Strategy Malta 2014-2024 | 2014 | - Aims to reduce traffic injuries and fatalities<br><br>-Main objectives to reduce injury and fatalities; to ensure safe design in new transport schemes; to provide a safe road environment for pedestrians and cyclists of all ages; to change the mentality of vehicle drivers to vulnerable road users; to promote safe routes to school |
| Strategic Plan for Environment and Development (SPED) | 2015 | - Aims to work in parallel with the development planning system to ensure an integrated approach to land use and transport planning<br><br>- Promotes sustainable travel modes are for areas of higher development and support policies which reduce use of unsustainable travel modes |
| National Transport Strategy 2050 | 2016 | Sets the vision and strategic goals for transport strategy for Malta to provide a sustainable transport system which is efficient, inclusive, safe, integrated and reliable for people and freight.<br><br>-The aim is to make urban areas conducive for active mobility, public transport use and inter-modal travel to reduce car dependency and its negative effects. |
| National Transport Master Plan 2025 | 2016 | - Sets out the framework and the overall priorities to guide transport investment in transport until 2025<br><br>- Aims to deliver a safer, secure, more sustainable and healthier transport system over the short-medium term. |
| Draft National Cycling Strategy | 2018 | - Aims to: 1) double the number of people who choose cycling as a mode of transport for trips less than 5km, by 2050 as compared to 2010; 2) reduce injuries involving cyclists by 50% by 2050. |
| Regulations for micromobility | 2019 | - Sets the regulations for the registration and use of micro-mobile modes such as e-scooters |
| Micromobility in the Maltese Transport System | 2020 | - Regulation of E-scooters which have to be insured, registered and licensed.<br>- Only persons with a driving license may ride an e-scooter.<br>- Sets the maximum speeds are 10km/h in pedestrian zones and 20km/h on the road.<br>- Use e-scooters on on arterial and distributor roads and tunnels is not allowed. |

The summary presented in Table 1.7, highlights the fragmented policy approach and lack of direction when it comes to transport planning in Malta. The policies set out are not aimed at specific targets nor follow a particular policy objective. Several barriers have been identified in the implementation of robust and targeted transport policies (Attard, 2005). These barriers have hindered the implementation of transport policies and led to a fragmented approach to transport policy making. One of the most important barriers to policy implementation which have been identified is the political situation in Malta. The two-party political system, where the results for government election is affected by a small shift in voting has led governments to refrain from introducing unpopular measures. For example, policies that aim to tax road usage or curb car used are viewed as unpopular and could pose a threat to re-election and are usually shelved.

In addition, the social element plays an important role with respect to car ownership. In Malta, the culture places high status on the ownership of the car (Attard, 2005). Throughout the years, a high status was increasingly associated with ownership of a car and lower status to trips made by public transport. This further aggravated the policy situation in the islands where policy-makers feared to upset motorist with unpopular transport polices. Public acceptance to policies which restrict car use was also a barrier to car-use reduction and politicians were reluctant to put into place policies which charge car users for driving in congested areas. In Malta, the Government was limited in the extent to which it could apply unpopular policies resulting in low policy intervention.

Despite the barriers to unpopular transport policies, a congestion charging system was successfully introduced in 2007. The Controlled Vehicular Access (CVA) system in Valletta, is a road pricing scheme which replaced an existing scheme (V-licence) where motorist who entered the capital city were charged an annual fee over and above the annual road licence. The CVA scheme was part of a larger transport strategy for Valletta which aimed at improving accessibility within the city. Other measures complementary measures which included the development of park and ride and an extension of pedestrianization in the city's retail area were also implemented to facilitate the charging scheme (Attard & Ison, 2015). The scheme was considered a success which saw the introduction of a concept which was not politically friendly, and which revolutionised travel by car (Attard & Enoch, 2011).

However, in 2013 government elections, one of the parties proposed a revision of the CVA system to make it easier and less prohibitive for people to access the city. The revision proposed that access to Valletta is free after 2 pm and on Saturdays. This measure was propositioned to stimulate commercial activity in Valletta (Partit Laburista, 2013). The party was elected in Government in March 2013 and proceeded with the implementation of this electoral promise. The new revised charging scheme started in November 2013, where no charges were induced for vehicles accessing the Valletta charging zone after 2pm on weekdays and all day on Saturdays, Sundays and public holidays (Times of Malta, 2013). This provides a good example of how the five-year government term and the political system in Malta influence transport policy making and how the validity of transport measures is affected once there is a change in legislature.

***The national transport strategy and climate change mitigation***

The vision of the first ever National Transport Strategy, published by Government in 2016 as an ex-ante conditionality imposed by the European Union[2], was to provide a sustainable transport system which is efficient, inclusive, safe, integrated and reliable for people and freight and which supports attractive urban, rural and costal environments and communities where people want to live and work now and in the future (Transport Malta 2016b). Within this vision, 6 strategic goals were identified. One of the goals is to provide a transport system that promotes Environmental and Urban Sustainability. To ensure environmental and urban sustainability, the transport strategy developed a number of aims, amongst which that to reduce and mitigate greenhouse gas emissions.

Furthermore, as part of the strategy's monitoring exercise that enables gauging the progress towards achieving the strategic goals and international commitments, strategic targets were set. The targets and indicators were also established with the purpose of guiding the transport planning process by establishing short and mid-term targets and long term goals. The strategic

[2] *Ex ante conditionalities are a set of legal provisions that Member States must fulfil in order to gain access to Funds European Structural and Investment (ESI) Funds. One criteria that Malta needed to fulfill to have access to funds for investment in transport infrastructure included the development of a national transport strategy and a national transport master plan with the support of a new national transport model is developed.*

targets established for the strategic goal on Environment and Urban Sustainability are summarised in Table 1.8.

**Table 1.8: Environment and Urban Sustainability Goals**

| | | Current | Targets | |
|---|---|---|---|---|
| **Strategic Goal** | **Indicators** | **2015** | **2030** | **2050** |
| Environmental and Urban Sustainability | Conventionally fueled cars | 99.9% | 50% | 0% |
| | Zero emission urban logistics | <1% | 95% | |
| | Average age of Passenger Cars (to 2014 EU Average) | 13.6yr | 8.5yr | |
| | Non-ETS Greenhouse Gas Emissions from Transport | 532 $ktCO_2$ equiv | 525 $ktCO_2$ equiv | |

*Source: Transport Malta (2016a)*

Placing the targets into context, in 2014, which is the base year for the national transport strategy, the total non-ETS emissions from road transport were at 589 $ktCO_2$ equivalent (Malta Resources Authority, 2017) . This means that the strategy targeted a 9.6% (57 $ktCO_2$ equiv.) reduction in emissions from the sector by 2015 and a 10.9% (64 $ktCO_2$ equiv.) reduction by 2030.

In the wider picture, in 2015, the total non-ETS emissions for Malta were at 1300 $ktCO_2$ equiv. while the annual emission allocations for Malta stood at 1165 $ktCO_2$ equivalent (a difference of 135 $ktCO_2$ equivalent) (European Commission, 2017a). This equates to less than half of the required emission reductions coming from the transport sector. While the Transport Strategy 2050 and Transport Master Plan 2025, identified several issues with Malta's transport system and recognised a number of measures that can be implemented for the transport system to move towards sustainable mobility, few of these measures have been implemented. This resulted in limited progress in ensuring sustainable transport and reducing traffic congestion (European Commission, 2020b). As emphasised in the Commission's report (European Commission, 2017) on Malta's progress towards the achievement of the joint EU targets, more can be done in the transport sector if the emission reduction targets are to be reached.

The figures presented above clearly indicate the need for more action from the transport sector to limit $CO_2$ emissions and contribute towards the attainment of the set climate change targets. This is even more important if Malta is to adopt the more stringent targets proposed by the

IPCC (80% emission reduction from the 1990 levels) rather than the limits set by the EU effort sharing decision.

## 1.4 Conclusion

This chapter has presented the research problem, provided an overview of the aim and objectives and introduced the case study. The next chapter, Chapter 2, will build on this introduction and present the findings of the literature review on climate change mitigation and transport studies, the approaches to climate change mitigation in transport, academic disciplines in transport research on climate change, emerging research approaches and research tools in transport climate studies. Chapter 3 discusses the theoretical framework underpinning this research which takes the Theory of Social Practices as the starting point and the research which this study aims to address. Chapter 4 introduces the research design, including the research questions, as well as the data collection and data analysis techniques employed. The subsequent chapters present the main findings of the study. Chapter 5 discusses the current mobility practices in Malta, Chapter 6 presents the results from the stakeholder workshop on transport futures in Malta, Chapter 7 presents the outcomes of the assessment of the different future scenarios and Chapter 8 discusses the policy pathways to more sustainable futures. Chapter 9 contains the discussion on the main findings, lessons learned and recommendations. The final chapter, Chapter 10, presents the conclusions of this research.

# CHAPTER 2: LITERARTURE REVIEW

## 2.1 Climate change mitigation and transport studies

The discussion until now has focused on the importance of climate change and how this environmental issue has become one of the major concerns of the 21$^{st}$ Century, the actions at both the global and the national levels aimed at mitigating the negative effects of global warming, and the contribution of transport to the GHG emissions and the potential that this sector has towards emission reduction and mitigation of climate change. Transport remains one of the largest (GHG) emission sources worldwide and emissions from this activity continue to grow. Transport accounts for approximately 25% of the global energy-related global $CO_2$ emissions (International Energy Agency, 2021a). Trend projections indicate how without any significant changes to the business as usual (BAU), GHG emissions from transport will be nearly double by 2050 (International Transport Forum, 2017). Although improvements in vehicle efficiency and modal shift may help to alleviate the growing emissions, these will still not be enough to lower emissions significantly (Lah, 2017). Keeping the global temperature rise below the 1.5°C and achieving the climate mitigation objectives therefore requires more radical efforts in transport (Allen et al., 2018).

To date, emission reduction from transport has proven to be difficult (Schwanen, 2015). One reason for such difficulty lies in the supporting role that transport plays in development and economic growth (Giorgi, 2003). Decoupling of transport from economic growth would therefore be needed to limit the unregulated expansion of the transport sector and its negative externalities while at the same time allow for growth – a path towards sustainability. The difficulty in moving towards low carbon mobility can be also conceptualised as a consequence of the multi-dimensionality and the complexity of the transport system and the decision-making process in transport (Banister, 2014). While transport is simply defined as the movement of people and goods in space and time, the notion of a transport system is much broader as it encompasses a set of elements which through their interaction enable both the movement of people and goods (Urry, 2007). These elements are not necessarily limited to the physical aspects such as the means of transport, fuels and infrastructure but also include immaterial elements like agencies, laws, rules, prices, norms and values.

A review of the published literature indicates how the research agenda that deals with climate change mitigation reflects the complexity and multi-dimensionality of the transport system (see for example (Creutzig et al., 2010; Karplus et al., 2010; Lohrey et al., 2016; Möser et al., 2008). It is understandable that due to such complexity, the reduction of $CO_2$ emissions cannot be achieved by targeting one element of the system alone but rather through a more holistic approach that brings together the interplay of the various elements. On the other hand, given the broad range of elements involved, the individual research studies in the field have often considered one sector of the transport system (private car, freight and aviation) and targeted one or a related group of transport elements. The broadness of this topic also heightens epistemological challenges and critical implications for the decision-making process. What follows is a review of the existing literature on transport research that deals with climate change mitigation.

## 2.2 Approaches to climate change mitigation in transport

An initial literature search in academic journals was carried using the key words “climate change mitigation”, “transport”, “climate action” and “climate change adaptation”. The systematic literature search was carried out through on-line databases (ScienceDirect, Scopus and ProQuest). The search included title, abstract and keywords and was limited to academic work. The resulting articles were then screened and assessed for the approach through which the climate change mitigation issue was addressed. The search under these criteria in all three databases resulted in a total number of 7, 200 publications. The first stage of the review, publications were evaluated for their fit with our study where all duplicates and non-climate records were removed. During this initial stage, records which were not related to the influence of climate change mitigation on transport were removed. The first stage of the literature process resulted process resulted in 208 records. The studies were then classified using a number of criteria namely, academic discipline, the transport element or aspect studied and the methodology employed.

A critical review about climate mitigation in transport was carried out by (Schwanen et al., 2011) with the purpose of developing a deeper understanding of the research topic and identify the prevailing research methodologies. The review served to explain the path-dependencies adopted in this area of scientific research and recognise the need for the contribution of other research disciplines. In view of this publication, the literature review presented in this study will aim at building on previous work and contribute to an update into the research on the decarbonisation of transport.

## 2.3 Academic disciplines in transport research about climate change

The link between transport and climate change has been studied both through the hard sciences such as engineering and technological change (Hopkins et al., 2018; Musti et al., 2011; Oshiro et al., 2015), but also from the point of view of (neo-classical) economics (Gupta, 2016; Musso et al., 2013). Though less evident, there is also literature from social sciences through disciplines such as geography (Heres-Del-Valle et al., 2011; Konadu et al., 2015; Schwanen, 2019; Temenos et al., 2017), psychology and behavioural sciences (Aziz et al., 2014; Henriksson et al., 2019; Ho et al., 2015) and sociology (Millonig et al., 2016).

### 2.3.1 A technological approach to transport studies

The focus on technological change as a means of bringing about the desired transition towards low-carbon mobility is the most recurrent theme in research dealing with transport and climate change mitigation. In parallel and maybe fuelled by the recent public discourses on sustainable transport and climate change, it is evident from research that technological advances and the diffusion of lower-emission vehicles or fuels are conceptualised as one of the most promising means of meeting the climate change targets. This observation may be reflected from the difficulty in shifting from what Miller (2001) identified as *car culture* and away from *societies of automobility* (Sheller et al., 2000). Cars and therefore *automobility* are deeply embedded in ways of life, networks of friendship and sociality, and moral commitments to family and care of others, and will not be easily given up just because they are environmentally destructive (Sheller, 2004). In such a scenario, technological change might present a good opportunity to overcome such a difficulty and at the same time minimise the emissions from transport.

Studies analysing the contribution of technological change to climate change mitigation have most often modelled the energy and emission reduction potential of alternative vehicle power trains such as the electric, hybrid technologies and hydrogen cell propulsion systems (He et al., 2013; Marcucci et al., 2012; Nanaki et al., 2016; Schipper, 2011; Sugiyama, 2012). Most notable is the literature that examines the potential of electric vehicles in mitigating GHG emissions (Nanaki et al., 2016; Raymand et al., 2021). Other research has sought to identify how different types of fuel such as diesel and natural gas can contribute to lowering the $CO_2$ levels from transport (Emonts et al., 2019; Gkatzoflias et al., 2012; Jayatilaka et al., 2015).

From a climate policy perspective, mitigation through the adoption of cleaner technologies is a continuity approach to overcoming carbon lock-in in transport. The term continuity approach was developed by Unruh (2000, 2002) in his analysis of the mechanisms leading to carbon lock-in and how these can be escaped. Industrialised economies have become locked-in into fuel-based energy and transport systems because of the way in which the development of technologies both influences and is influenced by the social, economic and cultural setting in which they develop (Kemp, 2000; Rip et al., 1998). This leads to the idea of path-dependency (David, 1985) where successful innovation and take-up of new technology depends on the path of its development which in turn is influenced by an interplay of technological infrastructures, organisations, society and governing institutions that create self-reinforcing barriers and which limit the change. The policy challenge lies in altering the current and quasi-stable technological systems to reach the desired environmental targets while limiting social disruption.

Policy makers tend to favour continuity approaches over discontinuity approaches. While such a preference is generally made with the intention of reducing the inertia to change, such an approach does not come without its shortcomings. One such limitation arises when a measure is perceived as being a continuous approach but acts as a discontinuous approach at a different system level, thus creating resistance. An example is the introduction of electric powered cars, which may seem as a continuity approach to the wider automobile system but presents discontinuity for the manufacturers of conventional fuel powered vehicles who would create resistance. Furthermore, continuity approaches may affect the performance of the whole system (in this case the transport system) for example by reducing efficiency (Unruh, 2002). While escaping technological lock-in is difficult to achieve, an insight into the different policy approaches such as that presented here in this study can provide important policy considerations.

### 2.3.2 The role of economic instruments

Apart from technological change and fuel efficiency, the emphasis on economic instruments as a means of enabling reduction in GHG emissions from transport and the contribution of behavioural change are equally important in transport research on climate change. Various options have been considered in an attempt to internalise the external costs of transport and correct market and policy failures. In climate policy, it is often common to implement market-based instruments such as carbon taxes, road pricing and cap-and-trade systems to internalise externalities and enable the regulator to control emission levels (Criqui et al., 2019; Nocera et al., 2015; Santos, 2017; Starkey, 2012; Wadud, 2011). Such policy instruments aim to reduce carbon emissions by signalling producers and consumers the scarcity of the atmospheric carbon sink and incentivising low-carbon activities (Creutzig et al., 2010; Marrero et al., 2020). In contrast to non-market instruments, market-based instruments enable the regulator to marignalise abatement costs within and across sectors without seeking techno-economic information, eliminate rebound effects and allow a level playing field for competing technologies. This does not however diminish the important role of non-market based instruments which act as complementary measures especially where there are market failures (Creutzig et al., 2010; Hammadou et al., 2015; Wadud, 2011).

Three levels of such carbon commodification strategies have been identified namely at the international level, at the regional or national level and at the personal or organisational level. Amongst these are international emissions trading (e.g. Clean Development Mechanism), trading schemes (e.g. EU ETS) and national carbon taxes, and voluntary carbon offsets (Bailey, 2007; Bailey et al., 2009; Gupta, 2016). While carbon and fuel taxes may be still seen as the ideal measure for addressing $CO_2$ emissions (David et al., 2014; Didelot et al., 2017) recent developments, both in the UK and other countries, have begun to focus on personal carbon trading (PCT) as an innovative instrument to achieve emission reductions (Fawcett, 2010; McNamara et al., 2013). In this type of scheme, individuals are allocated carbon credits which can be used for the required energy purchases, while surplus credits can be sold to higher carbon users according to prevailing permit prices (Bristow et al., 2010; Dogterom et al., 2018; Raux et al., 2015). As for efficiency and effectiveness, research on PCT has often demonstrated that such schemes are comparable to the more commonly used mitigation instruments such as carbon taxes (see for example (Starkey, 2012; Wadud, 2011). In the case of PCT in personal transport, the heterogeneity amongst transport users and the relative acceptability of different measures are determinants to the success of these schemes (Jovanović et al., 2013; Raux, 2008; Raux et al., 2015). Whilst being comparable to carbon taxes, PCTs offer the advantage of targeting individually generated carbon emissions and thus allow for citizen involvement in $CO_2$ emission reduction.

In parallel to the personal carbon trading schemes, city carbon budgets (CCB) or Local emission trading schemes (LETS) are another alternative economic instrument for achieving the emission reduction targets. As for PCTs, city carbon budgets target behavioural change and allow for individuals, households and communities to participate in meeting the challenge presented by climate change (Torres et al., 2011). In these schemes, which are a form of cap and trade system, local governments are assigned annual emission budgets and take the necessarily actions in transport and building emissions to remain within the set budget. The potential and success of economic instruments depends on several factors including amongst others the public's awareness, responsiveness and willingness to pay to target the problem of $CO_2$ emissions (Gupta, 2016).

Market-based instruments are centred around the assumption that travel decisions are based on rational models. These models predict travel behaviour as the result of individual's choice when subject to different transport alternatives. Based on these models, an individual selects the alternative that provides most benefit compared to cost. Market-based instruments enable the regulator to control emissions by putting a price on the emissions. In many cases, market instruments cannot optimally address the market failures such as climate change in transport. Their main problem is that they are often regressive, based on individualistic rational models which ignore the complexities of travel behavior (Carrasco et al., 2014). Transition to low-carbon mobility means transport research needs to move beyond the economic understanding of car use and mode choice and acknowledge that that are other influences such as the effect of spatial and temporal structural barriers and also the needs and desires of the travelling individual.

### 2.3.3 Behavioural change and transport

It is widely agreed amongst transport researchers that in addition to technological change, some degree of behavioural change is inevitable to bring about the required reduction in $CO_2$

emissions (Anable, 2005; Anable et al., 2006; Avineri, 2012; Banister, 2011; Brand et al., 2013; Bristow et al., 2010; Chapman, 2007; Economides et al., 2012; Metcalfe et al., 2012; Pye et al., 2014; Whitmarsh et al., 2021). Classic economic instruments represent one mechanism of shifting behaviour and decarbonising the transport system. The integration of other behavioural mechanism such as soft transport policy measures can be one way of overcoming the shortcomings of the so-called hard policy measures. This labelling as 'soft' downgrades the importance of changing behaviour, but which is central and the most difficult to achieve in the transition towards more sustainable mobility.

Soft policy measures can be described as those initiatives that are aimed at influencing individual travel choices or mobility behaviour less by using force and restrictions, but by changing people's perception and motivation. Social marketing technologies founded in psychological concepts like perceptions, values, attitudes and social norms are often used as the basis of formulating the soft policy measures (Möser and Bamberg, 2008). Soft policies share the individualistic view of behavioural economics where the focus is on the individual as the key agent of decision-making who chooses, interprets and ascribes meanings to travel patterns. In addition to bringing about the desired structural changes, behavioural change policies also focus on increasing the range of available choices to the individual for shaping his/her own life (Lehner et al., 2016; Pykett, 2012; Schubert, 2017; Thaler et al., 1999).

Various studies have been undertaken to assess the potential of soft transport policies in changing the travel behaviour patterns and ultimately reducing the emissions from transport (Dillman et al., 2021; Friman et al., 2013; Garcia-Sierra et al., 2015; Hollein et al., 2017; Riggs, 2017). Soft interventions which are informed by social psychology and are designed to influence or nudge choices (Meloni et al., 2013), have become more prevalent recently. Soft policies have gained popularity in the UK and European transport policies since they are publicly more acceptable and fit with the neo-liberal concepts of changing the individual's choice (Barr et al., 2014; Jones et al., 2011). There is a general agreement amongst these studies that soft transport policies, which are often aimed at inducing a voluntary change in the individual travel behaviour, have positive effects on the reduction of emissions from transport (Keskisaari et al., 2017; Magdolen et al., 2021). Such for example are studies by (Meloni et al., 2017) who found that 36% of their study participants changed their travel behaviour after the introduction of personalised travel plans. However, others argue that these results may be an overestimate of the positive effect that such policies may have on bringing about the required change (Brög et al., 2009). In view of such results, it is advocated that the effectiveness of soft policy measures can be achieved when these are combined with the hard transport policies (Bamberg, 2014).

### 2.3.4 Habits and sustainable transport

Further to the three theories outlined in the previous section, the theory of habits has also been employed to analyse how a shift towards more sustainable transport and hence reduction of $CO_2$ emissions from the sector can be achieved (Gärling et al., 2003; Linder et al., 2021; Matthies et al., 2006; Verplanken et al., 2021). Such research has often served to demonstrate the role of habits in guiding policy mechanisms (behavioural economics and soft policies) targeting behavioural change. Again, this approach is rooted in psychology and follows the work by research psychologist Verplanken (see for example (Verplanken et al., 1997) who recognised a gap between intention and actual behaviour in attitude-based theories particularly in the Theory of Planned Behaviour (TPB) and how habits can serve as a link between the two.

Habits can be described as behaviours that are developed through repetition and positive reinforcement. Three aspects have been identified as being pivotal for habits namely, a behaviour that is frequently repeated, has acquired a high degree of automaticity and is cued in stable contexts (Orbell et al., 2010). Hence, building on the definition of habits, the automatic responses must be disrupted or conditions eliciting such responses changed if a behavioural change is to be brought about (Darnton et al., 2011).

Habits are often a result of a set of interlinked elements (Dewey, 1922) and thus, it follows that for a behaviour change to materialise, a change in the interwoven set of elements needs to occur. Put in the context of the automobility system where most of the carbon-intensive travel habits are embedded, (Schwanen et al., 2012) argue that behavioural-change towards low carbon transport is more likely to occur if the behavioural change agenda is accompanied by a systematic change in which socio-technical systems governing automobility are strongly reconfigured. Other than reconfiguration of the socio-technical system, the availability of alternative habits is also important in assuring a change in travel behaviour (Stern, 2000).

### 2.3.5 Land use and the contribution of infrastructure

The critical analysis of the literature presented so far demonstrated how research on climate change mitigation in transport examined how reduction of GHG emissions from the sector can be achieved through a change in technology, using economic instruments and by altering travel behaviour. Other than these themes, it is also evident how research has also explored the potential contribution of transport infrastructure, urban design and land use planning to mitigate climate change.

With the growing rate of urbanisation, the potential that planning of the urban structure has in providing the physical means to encourage more sustainable travel is increasingly being acknowledged (Hickman et al., 2010). Urban planning has the potential of affecting the vehicle miles travelled and thus contribute to the reduction of $CO_2$ emissions. Scholars in urban geography have often advocated how urban designs favouring high densities which lead to more efficient cities with a lower need for travel and therefore lower environmental impact (Ewing et al., 2001; Lohrey et al., 2016; Newman et al., 1999). Various built environment variables have been incorporated in urban design strategies, most notably are the 3Ds (density, diversity and design) (Cervero et al., 1997), to which distance to transit and destination accessibility were later added (Cervero & Murakami, 2008). In transport and climate change research, the DDD of sustainable urbanism has often been used as the basis of analysing the changes required to reduce emissions. Analytical frameworks for such an analysis have also incorporated the use of models such as Schipper's ASIF (avoid, shift, improve, finance) model (Tiwari et al., 2011).

Despite the general agreement that urban design contributes to the distance travelled and hence the emissions from transport, there are contrasting views on the effectiveness of urban form on the reduction of vehicle miles and GHG emissions. Evidence of lower auto ownership rates in areas of high urban densities and use of non-motorised travel modes where there is low provision of non-motorised infrastructure contrasts with other claims that the relationship of urban form and auto ownership is dependent on other factors such as self-selection for different mobility types (Cao et al., 2009; Cervero & Duncan, 2008; Schwanen et al., 2005). Urban form is only one aspect of a complex rationale that determines travel. The relationship between travel and urban structure is not a simple and linear one (Hickman, 2013). A closer relation of travel behaviour also demonstrates that complex relationships do not only exist between the urban form and travel distances but also include interactions with socio-economic factors and attitudes and which are also dependent on different geographical context (Gordon et al., 1997). Further to urban design, the provision of transport infrastructure is also known to contribute to the pattern of GHG emissions from urban areas (Guivarch et al., 2011). Traditionally, transport policy was focused on the predict and provide paradigm and the building of roads was one way of improving congestion and thus reducing the negative externalities of transport. However, the need of a shift from such a paradigm has been increasingly recognised especially since the work of (Goodwin, 2006) and his empirical evidence that the provision of extra road capacity results in a greater volume of traffic. Provision of infrastructure that favours motorised transport can also contribute to the formation of adverse path dependencies (Fenton, 2017).

One of the key issues for climate change mitigation is that infrastructure has a long lifespan, signifying that decisions and changes made at one point are likely to last for several decades (Birch, 2016). Failure to integrate climate change mitigation into the planning, design and development could reinforce carbon lock-in (Unruh, 2000). This infrastructure lock-in has important implications as it could create physical limits that would inhibit sustainability transition pathways (Birch, 2016). It is therefore critical that climate change mitigation is incorporated into planning of infrastructure now to avoid ending up with provisions which are unsuitable for the next century. Such planning includes the provision of effective infrastructure such as cycle lanes, walking pathways and bus lanes (Gehl, 2013; Pucher et al., 2010; Stone et al., 2010) that allow for more sustainable travel (Holz-Rau et al., 2019; Lohrey et al., 2016).

## 2.4 A reductionist approach to transport research

The literature review presented so far has served to highlight the variability within academic research dealing with climate change mitigation in transport. One aspect that becomes evident following this review is that most often the individual research studies have focused on one element of the transport system or a set of elements of the more complex system. Such is the example of research dealing with the contribution of technology towards climate change mitigation or the importance of economic instruments in reducing the emissions from transport. Other studies have analysed multiple elements, for example the role of technology and behaviour in low-carbon mobility, yet few are the studies that have looked at the interactions between the various elements of the complex system.

### 2.4.1 Issues with the reductionist approach

While this approach allows for a more focused analysis of the contribution of the different transport elements and their potential in the decarbonisation of the transport system, it fails to capture the possibility that the different agents may influence one another, leading to positive feedbacks. This reductionist perspective, has the tendency of splitting complex phenomena into simplistic analytical models and isolate objects from each other. The reductionist approach is based on the classical Newtonian theory that defines systems as conglomerates of distinct parts that may be broken down in parts then re-aggregated into functioning systems again. In this so-called *paradigm of simplification* (Morin, 2008), the macro system behaviour is understood to be the result of aggregated micro properties, but without considering to a full extent the interactions between agents. The reductive approach breaks down when the systems are turbulent, self-organising and interactive in multiple directions (Espinosa et al., 2011). The idea of the reductionist approach emerges following the complexity theory which in contrast acknowledges that many system properties emerge solely from the interaction between agents and not from the behaviour of agents themselves.

Reductionist approaches are known to have limited capabilities in the analysis of sustainability challenges (Huutoniemi et al., 2014a). On the other hand, taking a complexity theory perspective in sustainability transitions brings a number of advantages where phenomena such as the diffusion of innovations, learning by doing, trends and fashions, and technology lock-ins amongst others can be captured and better understood (Mercure et al., 2016).

## 2.5 Emerging Research Approaches

As discussed in the previous sections, research on transport and climate change mitigation is diverse and researchers have investigated the issue through different disciplines and perspectives. The research shows a strong emphasis on the role that technology plays in reducing transport emissions, how economic instruments and land use planning can influence travel and how behaviour of individuals can be altered through information campaigns and social marketing. These approaches, while offering a valuable contribution towards the understanding of the issues surrounding climate change and transport, provide only a partial understanding of the problem. Taking such approaches in transport research means that important facets of climate change mitigation are not fully contended. Amongst some of these facets that transport research is not addressing when it comes to climate change mitigation include the societal embedding of transitions to sustainable forms of transport, the uncertainty that new interventions can bring about and the non-linear behaviour of individuals (Schwanen et al., 2011; Shove et al., 2015b).

In the light of this gap in the research, new research is emerging that has the potential of confronting the uncertainties and the complexities of transport decarbonisation. One of the emerging research traditions that can provide alternative insights and help moderate the limitations of the reductionist and positivist approaches is the social practice perspective (Shove et al., 2012).

Sustainability transitions prove to be challenging because they are rooted in strong-path dependencies and intertwined with user practices and lifestyles (Markard et al., 2012). The Theory of Social Practice offers new insights into the study of socio-technical change and promises to provide new footholds for more radical interventions required in sustainability transitions (Welch et al., 2018). The next section will focus on a discussion of how the Theory of Social Practice can provide new insights to inform sustainable transitions.

### 2.5.1 Theories of social practice as emerging research themes

The Theory of Social Practice is rooted within the social sciences. However, it is very distinct from other theories within this academic discipline. Most of the theories in social sciences have emerged from classical theories of action where the agents at the centre of the analysis are either self-interested individuals or norm-following and rule-conforming social actors (Reckwitz, 2002). On the other hand, social practice theories move away from the individual or structural modes of action and propose that the social life is made up of social practices in which the individuals participate (Yolande et al., 2015). The Theory of Social Practice aims to bridge the gap between the individualistic and systematic/structural approaches in social science.

On one side of the gap, there are those approaches that seek to alter the individual's attitudes, and help people make choices towards a behaviour which is more sustainable. These approaches, also described as the ABC (Attitude, Behaviour, Choice) model (Shove, 2010a), are criticised as being individualistic focusing on the individual's choices of behaviour without taking into consideration the elements, processes and dynamism of the relations between the elements which are characteristic of complex systems such as the transport system. These individualistic approaches, which are based in social psychology and often use education, awareness or persuasion, are popular with policies governing the shift towards sustainability (Moloney et al., 2010; Watson, 2012).

Other than the individualist approach, the systematic/structural approach is another dominant paradigm amongst the policy approaches in the environment and climate change aspect. In the systemic paradigm, which to some extent is a reaction to the failures of the individualist strategies, the policy focus is on the institutional actors such as organisations, NGOs and producers. In contrast to the other paradigm, the individual is no longer at the centre and the shift towards sustainable behaviour is enforced through regulations (Spaargaren, 2011). A comparative analysis between the two paradigms is given in Table 2.1. As with the individualist paradigm, the systemic or structural paradigm has received quite substantial criticism in view of its effectiveness in bringing about behavioural change. The problem with the latter seems to result from the lack of participation of the human agents in the environmental change process (Schot, 2001).

**Table 2.1: Comparison between two paradigms for governing behavioural change in environment.**

| **Individual Paradigm (social psychology/economics)** | **Systemic Paradigm (social/science studies)** |
|---|---|
| Individuals and their attitudes are key units of analysis and policy | Producers/states and their strategies are key units of analysis and policy |
| Behavioral change of individuals is decisive for environmental change | Technological innovation within the production sphere is decisive for change |
| Individual choices are the key intervention targets (micro level) | Socio-technical systems are the key intervention targets (macro-level) |
| End-users/consumers determine the fate of green products and ideas | Technologies and markets determine the fate of green product ideas |
| Key policy instruments and approaches: social (soft) instruments (persuasion through information provision) | Key policy instruments and approaches the use of direct regulation targeting providers (laws, market based instruments) |

*Source: Spaargaren (2011)*

In contrast to the more conventional top-down or bottom-up approaches, theories of social practice allow a better integration of the roles of both human actors, culture and technological infrastructures in transitions towards sustainability (Birtchnell, 2012; Spaargaren, 2011). Theories of practice decentralise the individual and make behavioural practices at the centre of the analysis (Collins, 2004). Second, the focus is not on specific and isolated behavioural items but is based on a designated group of actors and their potential in reducing the environmental impact of their normal daily routines. Third, social practice approaches analyse transitions to sustainable lifestyles in distinct domains of social life, thus bringing social structures at the centre of the analysis rather than being treated as external variables (Spaargaren, 2003).

The application of theories of practice to research in sustainability and climate change mitigation in transport is only recent. Most work has been done in environmental debates on sustainability transitions (Shove et al., 2007; Spaargaren, 2011). In the UK especially, work in the lines of practice theories and sustainability has been pioneered by Shove and her colleagues (Shove et al., 2012; Shove, 2010b). Despite receiving some criticism (Corradi et al., 2010) practice theories can contribute towards transitions to low-carbon lifestyles. Watson (2012) identifies two ways in which practice theories which can help to sustain transitions towards sustainability. First, the elements of practice are subject to change. So are the people carrying the practice and the relation of one practice to one another. Birtchnell (2012) argues that the reconfiguration of the elements (including practices, technologies and products), by elites (exemplars that champion and perform new practices) and events are important in the process of systemic transitions. These characteristics of practices, allows for innovation, which is an important aspect in transitions to sustainability (Spaargaren, 2003).

A practice approach to sustainable mobility presents epistemological challenges in transport research that deals with climate change mitigation. Since the approach is innovative and different from other approaches adopted in transport research, new methods for data generation and modes of analysis must be sought to accommodate the practice perspective. This aspect of social practice-based approaches to sustainability transitions will be discussed in Chapter 3 (Section 3.7).

## 2.6 Research tools in transport climate studies

The complexity of sustainability issues combined with a high degree of uncertainty that is also characteristic of such societal problems have important epistemological implications. The *wickedness* (Murphy, 2012) of sustainability issues puts limits on how these can be solved through traditional methods and disciplinary thinking. Interdisciplinary and transdisciplinary thinking are gaining popularity in academic research aimed at exploring non-disciplinary methods of inquiry as a means to solve sustainability problems. Huutoniemi and Willamo (2014b), introduce the concept of heuristics approaches as applied to transdisciplinary research as a methodological alternative in sustainability research. As in pragmatism, heuristics allow for opportunism and flexibility while acknowledging the empirical diversity of the many methods in different sciences. Transdisciplinary heuristics offers an opportunity to framing sustainability problems or finding useful ways to define the situation that a problem represents.

Transdisciplinary heuristic approaches have also found their application in the framing of sustainability problems in transport research. Review of the scientific research dealing with climate change mitigation and transport illustrates various methodologies and analysis choices applied in the field. Despite the common aim, that of making clearer how to overcome the challenge that the transport sector poses to sustainability, different approaches have been adopted to meet this research objective. The choice of the methodology is very much linked with the research questions being addressed, the type of data available and the desired output of the study. One approach in transport research that allows for transdisciplinary heuristic studies is scenario analysis. Scenario analysis provides a heuristic device for helping diverse stakeholders to identify, deliberate, and explore key assumptions and decisions (Rickards et al., 2014). Scenarios can be defined as alternative future images to the current unsustainable trends images (Tapio et al., 2014). The tool is particularly useful to transport planning as it allows for an understanding of multiple interlinking social, economic and technological issues (Lyons et al., 2021). The scenario analysis approach to climate change in transport is diverse involving different techniques and methods of analysis. The next section will present a discussion on the different typologies of scenario analysis.

### 2.6.1 Scenario analysis

***Definition***

Scenarios may be described as coherent and plausible stories, told in words and numbers, about the possible co-evolutionary pathways of combined human and environmental systems (Swart et al., 2004). Scenarios are a description of a future situation and the set of conditions that allow the development of these futures from the current situation (Godet, 2000). Scenario planning generally involves outlining the possible futures, capturing a wide range of options, stimulate thinking about the future and challenging the prevailing mindset and status quo (Schoemaker, 1991). The advantage of scenario analysis is that the technique allows the consideration of multiple possible future alternatives to conduct future planning in a holistic manner (Burt et al., 2003). It significantly enhances the ability to deal with uncertainty and the usefulness of overall decision-making process (Van Der Heijden, 1996)

Future studies date back to the post-war period where RAND and Stanford Research Institute developed methods using probabilistic and trend-based approaches to identify probable futures (Chermack et al., 2001; Curry, 2021; Yan et al., 2009). Later on, the Hudson Institute also started looking into developing future studies. This led to businesses such the oil company Shell to start thinking about the future and applying scenarios to the business challenges of the oil sector in 1970 (Wilkinson et al., 2013). The Massachusetts Institute of Technology was also using similar concepts to describe supply and demand chains (Chermack et al., 2001). The success and innovation with such scenario building encouraged other organisations to start thinking about the future. Scenario analysis also started to be adopted at national level to assess different strategic futures.

Different methodological designs, modelling frameworks, data used and scenario results are possible (Ajanovic et al., 2017; Cochran et al., 2014). The broad term ranges from narrative descriptions of future alternatives to model-based projections, from simple deviations of the business-as-usual approach to more explorative possibilities. Swart et al. (2004) view this diversity in methodological applications of scenarios as a strong point that allows flexibility and creative thinking, a requirement when dealing with complex problems and a diverse range of aims.

### *Typology of Scenarios*

Scenario types can be very varied, and scenarios have often been classified into different classes. However, there is no consensus on the scenario typologies. Most of the typologies used to classify scenarios are based on the view that scenarios can be used to explore possible, probable, and preferable futures. Van Notten et al. (2003) for example, classify scenario studies into overarching themes that describe the project goal, the process design, and the scenario content. These themes are then further divided into fourteen specific characteristics are used to define the scenarios as illustrated in Table 2.2

Other scenario typologies are based on three categories of scenario studies. For example, the classification scenario typologies by Börjeson et al. (2006), is based on the what the user needs to know about the future whether it is what will happen (predictive), what can happen (explorative) or how a predefined target can be achieved (normative). Each category is then further divided into different sets giving rise to six scenario types. This classification is shown in Figure 2.1.

**Table 2.2: Typology of scenarios**

| Overarching Themes | | Scenario | Characteristics |
|---|---|---|---|
| A | Project goal: Explorative vs decision support | I. | Inclusion of norms: Descriptive vs normative |
| | | II. | Vantage point: forecasting vs backcasting |
| | | III. | Subject: Issue-based, area based, institution-based |
| | | IV. | Time scale: long term vs short term |
| | | V. | Spatial scale: global/supranational vs national/local |
| B | Process design: intuitive vs formal | VI. | Data: qualitative vs quantitative |
| | | VII. | Method of data collection: participatory vs desk research |
| | | VIII. | Resources: extensive vs limited |
| | | IX. | Institutional conditions: open vs constrained |
| C | Scenario content: complex vs simple | X. | Temporal nature: claim vs snapshot |
| | | XI. | Variables: heterogeneous vs homogeneous |
| | | XII. | Dynamics: peripheral vs trend |
| | | XIII. | Level of deviation: alternative vs conventional |
| | | XIV. | Level of integration: high vs low |

*Source: Van Notten et al. (2003)*

Predictive scenarios aim to predict what is going to happen in the future given a set of conditions or some specified events. The objective of these scenarios is to determine the situations that are likely to occur and make it possible to plan or adapt to such situations (Amer et al., 2013). These types of scenarios are useful to planners who need to deal with foreseeable futures or decision-makers who need to be aware of the problems that are likely to arise (Van

Der Heijden, 1996). Predictions are usually based on historical data which determines the outcomes of the future.

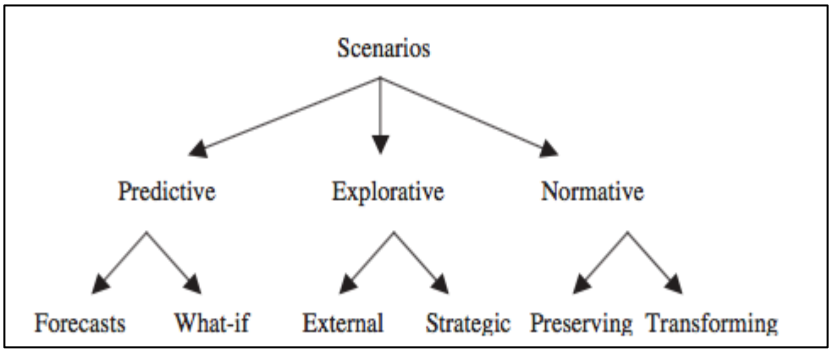



**Figure 2.1: Scenario Classification**
*Source: Börjeson et al., (2006)*

Explorative scenarios on the other hand aim to explore situations that are regarded as possible to happen. Explorative scenarios are elaborated with a long time frame. Explorative scenarios are usually used in the case of strategic issues. The focus of the normative scenarios is on certain future situations or objectives and how these can be achieved. Preserving scenarios are used when the future can be achieved with the current system structure while transforming scenarios require system changes to allow for the target futures to be realised. The starting point of the transformation is a highly desirable future which is not feasible if the ongoing development continues (Amer et al., 2013; Börjeson et al., 2006).

Scenario building methods have also found application in transport and climate change research (Aggarwal et al., 2016; Hickman et al., 2014). These methods of analysis aid the transport planning process where scenario analysis is particularly useful to explore the issues related to mobility and sustainable development. The main objective of the application of scenario analysis is to develop more effective strategic decision-making in view of uncertain trends, and to understand the potential for achieving breaks against dominant trends (Hickman et al., 2012). Scenario analysis is an important tool in transport research as it allows decision-makers to think about the longer-term futures and address the uncertainty and potential unintended consequences of these futures (Lyons et al., 2016).

### 2.6.2 Backcasting Techniques

Normative scenario analysis has been widely used in sustainability studies where major structural changes need to be overcome to reach the desired future (Holmberg et al., 2000). These scenario methodologies, which include backcasting, has often helped to address the need to think about the longer-term futures, to address uncertainty and potential consequences of complex problems such as sustainable transport (Lyons & Davidson, 2016). Backcasting aims to explore divergent and innovative policy trajectories to reach a desirable future when the business-as-usual direction is no longer appropriate (Höjer et al., 2000).

Backcasting approaches provide advantages over the other forms of scenario building especially when dealing with complex long-term sustainability problems (Dreborg, 1996). Taking a particular point in the future as a starting point is said to provide freedom from present socio-cultural norms and technological and institutional constraints to create visions that can illuminate opportunities for more radical change compared with thinking from the present situation (Müllert et al., 1987; Quist, 2007). It is recognised as an effective approach to explore how a certain target could be met when contemporary structures block the changes sought. These characteristics of backcasting has made the methodology attractive to policy-makers and scientists in sustainability studies and has been considered as an important tool when dealing with issues such as climate change (Giddens, 2009).

The method, which was first used in energy future studies, has been described by Robinson (1982) who stated that:

*"the major distinguishing characteristic of backcasting analysis is a concern, not with what futures are likely to happen, but with how desirable futures can be attained. It is thus explicitly normative, involving working backwards from a particular desirable future end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point."*

Backcasting has been developed from earlier approaches in which futures were analysed through normative forecasting, which was used amongst others to set goals in technology development. Emergent work based on backcasting was observed in the 1970s where the feasibility of different normative future options and their policy implications were studied (Lovins, 1977; Robinson, 1982). Backcasting continued to be developed later in the 1990s particularly in the Netherlands, Sweden and Canada. Different aspects to the backcasting approach were introduced and the approach was applied in a variety of domains such as households, climate policy and local or regional planning (Holmberg et al., 2000; Vergragt, 2005; Vergragt et al., 1993). The projects which adopted the backcasting approach were inspired by sustainability and assumed that a radical societal transformation is necessary to achieve the desired goals (Vergragt et al., 2011).

Backcasting is characterised by two central elements namely, the development of images of desirable futures and the elaboration of pathways of transition connecting these futures to the present (Robinson, 1990). The technique is advantageous because it allows the addressing of complex problems in ways that permit individuals and decision-makers to articulate viable courses of action that point towards the desired future. In addition, it stimulates the development of scenarios away from the trends of the present and with a focus on the desired future state, and while doing so, it eliminates the effects of the socio-technical path-dependency (Wangel, 2011a). Backcasting is advantageous when used to solve long-term complex issues that involve many aspects of society and technological innovation and change. In contrast to other methods of problem-solving and future studies, backcasting is recognised as being well suited for tackling major societal problems requiring more than marginal changes at the many levels of society (Steen et al., 1999).

Dreborg (1996) identified a number of characteristics describing societal issues which could be remediated through backcasting processes:

a. *when the problem is complex, affecting many sectors and levels of society*
b. *when there is a need for major change,*
c. *when the dominant trends are part of the problem*
d. *when the problem to a great extent is a matter of externalities, which the market cannot treat satisfactory*
e. *when the time horizon is long enough to allow considerable scope for deliberate choice*

Despite there being no standard method or approach for developing backcasting scenarios, a general guideline can be found in literature. Robinson (1990) and van Wee and Geurs (2004) give a general outline of the backcasting approach (Figure 2.2). In backcasting analysis, future goals and objectives need first to be defined and then used to develop a future scenario. In the iterative backcasting process, the scenario is evaluated and changes to the scenarios are made where necessary to resolve inconsistencies and mitigate impacts that are revealed in the course of the analysis.

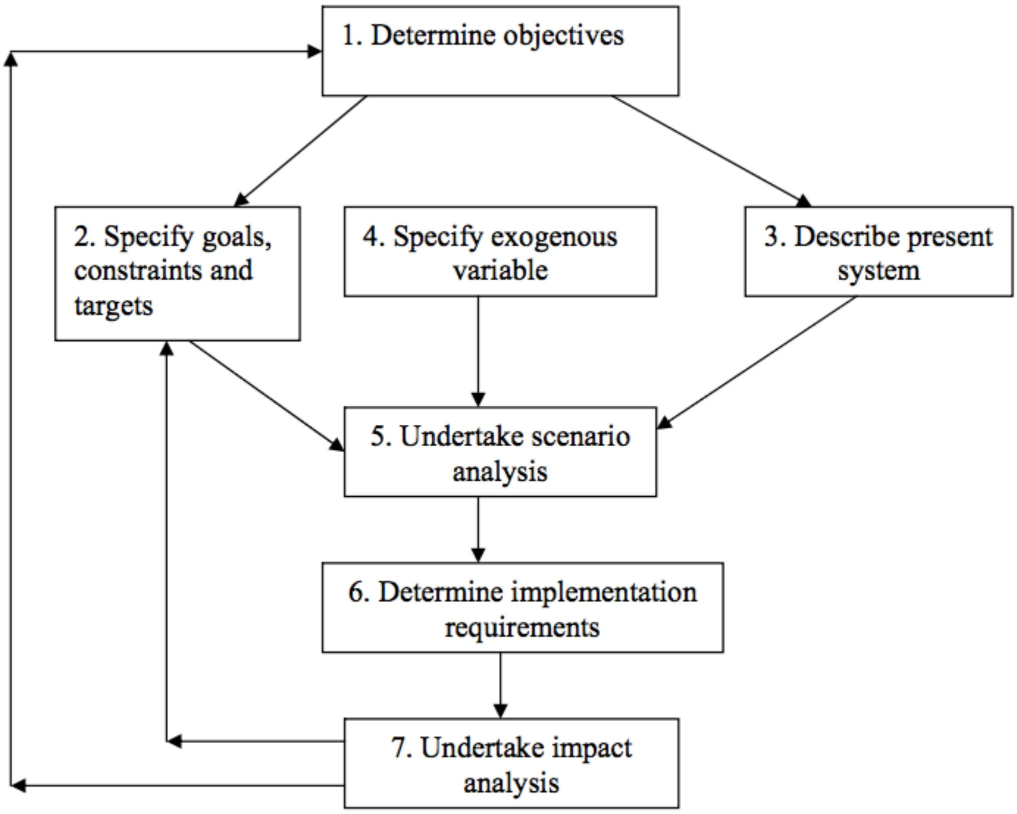



**Figure 2.2: Outline of backcasting approach.**
*Source: Van Wee et al., (2004)*

While the framework for backcasting as described by Robinson (1990) and outlined by van Wee and Geurs (2004) is useful for structuring the analysis, it does not constitute a formal method for backcasting studies. This is reflected in the variety and diversity of the backcasting studies in literature. One key area in which different backcasting studies differ is how the normative scenarios are developed or who develops scenarios. The approach of backcasting has also seen some developments over the years and now the methodology has also been broadened to include participatory analysis that allow stakeholders to express their views on what futures are desirable (Carlsson-Kanyama et al., 2008; Kok et al., 2011; Quist et al., 2006; Robinson et al., 2011; Van Berkel et al., 2012).

### 2.6.3 Backcasting in transport studies

The backcasting approach has found good application in the field of transport and climate policy. The methodology involves taking a normative view of desirable endpoints in the future, and then examining the means and pathways by which those futures can be reached (Soria-Lara & Banister, 2017). There is a wide ranging literature that cover the methodology and issues encountered and lessons learnt during the backcasting studies (Banister et al., 2000; Geurs et al., 2010; Hickman et al., 2011; Mattila et al., 2011; Olsson, 2015; Soria-Lara et al., 2017b; Tuominen et al., 2014).

While there is no single methodology amongst backcasting studies in transport research, a number of stages can be identified. The first step usually involves establishing the baseline and the business-as-usual projection for the long-term future (25 to 30 years) (European Commission Joint Research Centre, 2008; Geurs et al., 2010; Robin Hickman et al., 2010; Hickman et al., 2011; Hickman et al., 2007; Julio Soria-Lara et al., 2018). The next step then involves the visioning phase where a series of images of alternative futures are constructed. This visioning phase can take different forms depending on the aim of the backcasting study. In particular backcasting exercises, a wide variety of actors are involved in the drawing-up of normative views of desirable future end-points (Wangel, 2011a). The following step would involve the design of policies or policy-packages that can achieve the normative scenarios constructed in the visioning phase (Banister et al., 2013). In addition to suggesting policies to achieve the desired future, this phase also determines the time-frames for their implementation. Following this phase, the policy packages are then appraised against the end-goal of the backcasting study. This involves testing the effectiveness of the policies in terms of reaching the target future transport goal.

In the scenario building process, a combination of both quantitative and qualitative data is often employed. Backcasting is implemented by either conducting desk research or workshops with a small group of experts in the field. However, in the case of unstructured problems where there are conflicting interests and high uncertainties, such as is the case of transport and climate change, backcasting may necessitate the involvement of different stakeholders. The involvement of stakeholders can help to overcome the diverging views and interests and address the underlying assumptions (Hisschemöller et al., 1995; Wangel, 2011b). The actors that lead the scenario development process have important implications for scenario analysis.

The outcomes of the backcasitng process will produce different results depending on whether it is driven by experts or involves the participation of a wide range of participants including experts and non-experts (Nikolakis, 2020). The involvement of different stakeholders increases support and involvement in the follow-up of the methodology and makes stakeholder expertise available. Stakeholder participation can contribute to structuring complex problems and bring into the process a wide range of perspectives (Quist et al., 2011a).

Increasingly participatory approaches based on stakeholders' participation and interaction are finding application in the context of transport planning (Bertolini et al., 2019; Curtis, 2008; Innes et al., 2010) and backcasting approaches. Participatory approaches consist of the interaction of different stakeholders rather than the deliberation of only experts or one group of actors. This approach is focused on participation, stakeholder learning and reconciliation of different ideas from a diverse group of actors (Gordon, 2020). Participatory approaches allow for reconfiguration of the transport planning process from one which is based on instrumental rationality to one based on discussion and consensus seeking (Innes et al., 2010; Willson, 2001). As some researchers note, (Guy et al., 2000; Elizabeth Shove et al., 2012) a key contributor to socio-technical lock-in and system inertia is the lack of discussion between stakeholders in a particular socio-technical systems (such as transport). Participatory backcasting exercises bring together different participants, including experts and non-experts at various points in the process. Participation of different actors introduces a range of inputs, mind-sets and interests, and stimulates learning (Meadowcroft, 2009; Quist, 2007). A collective visioning process which allows for the stimulation of higher order learning can be stimulated. Higher order learning is defined as *learning processes not only on the cognitive level, but also with respect to values, attitudes and underlying convictions* (Quist et al., 2006).

The degree of involvement of different stakeholders can vary and span from simple involvement of different groups to express their views to high participatory approaches where a large number of participants are involved in the process (Zimmermann et al., 2012a). The method chosen for stakeholder involvement allows different degrees of influence (Kerkhof et al., 2005; Quist, 2007). The choice of stakeholders is another influencing factor in backcasting studies. Involving stakeholders that have an interest in the issue being explored and who are willing to develop and discuss alternative future visions is considered to be essential in participatory backcasting (Quist et al., 2011a).

The backcasting approach has been at the basis of a number of transport projects that examined sustainable mobility and climate change policy in transport. These studies included European transport projects that assessed the environmental sustainability of transport policies (OECD, 2000) and the feasibility of European transport policies and their suitability to deliver sustainable mobility (Banister et al., 2010). In addition to these European studies, other research has used the backcasting approach to explore sustainable transport futures, both within the European Union and other areas. Table 2.3 provides a summary of some of these studies with the aim of demonstrating the wide applicability of the approach.

**Table 2.3: Transport studies using a backcasting approach**

| Study | Main Characteristic | Reference |
|---|---|---|
| Policy Scenarios for Sustainable Mobility (POSSUM) | A set of images and policy pathways are developed for 25% reduction of $CO_2$ emissions from transport – desk-based research | (Banister et al., 2000) |
| Environmentally Sustainable Transport | Alternative policies are constructed for sustainable transport in 2030, these are assessed against social and economic criteria. The policies are developed by the researchers | (OECD, 2000) |
| Impact of ICT on Transport (ITCRANS) | Explore a series of scenarios how ICT can impact mobility | (Wagner et al., 2004) |
| Towards the decarbonisation of EU transport sector by 2050 | Modelling exercise to develop different emission scenarios | (Skinner et al., 2010) |
| Sustainable freight transport systems for Europe 2050 | A shared vision and an action plan of a sustainable freight transport system for 2050 was developed among the stakeholders, using interactive discussion workshops. | (Mattila et al., 2011) |
| Assessing the success of electromobility in Germany | Delphi surveys and interviews used as a means of stakeholder engagement to develop future visions of electromobility | (Zimmermann et al., 2012a) |
| Sustainable transport Policy in the Netherlands | Scenarios are constructed using expert judgement, existing literature and model simulations | (Van Wee et al., 2004) |
| Transport policies toward future emissions reduction for Stockholm 2030 | Alternative transport futures are constructed using a modelling exercise | (Robèrt et al., 2006) |
| Evaluation of the impacts of Autonomous Vehicles | Expert surveys were used to evaluate different scenarios for the implementation of autonomous vehicles | (Nogués et al., 2020) |
| Carbon-Efficient Transportation in the UK | Participatory stakeholder focus groups to develop policy packages for $CO_2$ emission reduction from transport | (Banister et al., 2013; Hickman et al., 2009; Robin Hickman et al., 2010; Hickman et al., 2011; Hickman et al., 2005, 2007) |
| Policies for reduction of $CO_2$ emissions in Finland – visions, scenarios and pathways | Engaging participants through a Delphi survey to formulate transport futures with lower $CO_2$ emissions | (Järvi et al., 2015; Tuominen et al., 2014) |
| Pathways to decarbonise the European Car Fleet | Model based approach to develop different future scenarios | (Höltl et al., 2018) |
| The Tyndall decarbonization scenarios | Participatory stakeholder engagement to develop alternative energy scenarios including those for transport | (Anderson et al., 2005; Anderson et al., 2008; Mander et al., 2008a) |
| Backcasting studies for Swedish transport | Evaluation of different transport scenarios using backcasting | (Åkerman et al., 2006; Steen, 1997; Steen et al., 1999) |
| Assessment of different transport policies for GHG emission reductions in France | Model based approach to the assessment of different scenarios for passenger transport | (Lopez-Ruiz, 2010; Lopez-Ruiz et al., 2010) |
| Transport backcasting studies for sustainable transport in Spain | Participatory stakeholder engagement for developing sustainable transport futures for Spain | (Julio Soria-Lara et al., 2018; Soria-Lara et al., 2017a, 2017b; Julio A. Soria-Lara et al., 2018) |

The comparative review of transport studies based on backcasting presented in Table 2.2 is also useful to illustrate the diverse set of methods used in conjunction with the backcasting methodology. For example, backcasting transport studies differ in the type of participatory methods used, in the number of steps in the methodology, the technique employed to construct scenarios, the target or focus of the process, the nature and scale of the systems addressed, the number of visions developed and if the focus is on learning and raising awareness among stakeholders, or producing a set of future visions for further follow-up and implementation. The review of the literature also shows that some research emphasises stakeholder participation during the visioning phase of the backcasting process while others also engage participants in finding a viable pathway that can lead to the realisation of these visions.

### 2.6.4 Methods of scenario evaluation in backcasting studies

Literature on backcasting studies illustrate how scenarios developed from the visioning phase of the process are subject to some form of sustainability assessment (Åkerman et al., 2006; Hickman et al., 2012; Julio A. Soria-Lara et al., 2018). This assessment provides an indication of the suitability of the scenario for reaching the sustainability goals and is important for subsequent phases of the backcasting process. The sustainability evaluation of scenarios is especially important in the case of target-oriented backcasting (Börjeson et al., 2006) where the aim of the scenarios is to reach a quantifiable goal such as that of emission reduction.

Amongst the backcasting studies several different techniques have been employed in the evaluation of scenarios. Within the range of techniques for scenario evaluation, one can find both quantitative and qualitative methods. Sustainability appraisals for example are one set of assessment tools that allow for the simultaneous assessment of environmental, social and economic impacts of a scenario or decision. These types of assessments typically rely on semi-quantitative or qualitative data for analysis (Giurco et al., 2011; Nijkamp et al., 2000; White et al., 2006). Multi-criteria analysis is one example of a sustainability appraisal that relies on a qualitative methodology for the assessment of different scenarios. This type of appraisal has found application in backcasting exercises in transport policy (Hickman et al., 2012; Julio Soria-Lara et al., 2018). Other backcasting projects have relied on the quantification of $CO_2$ emissions resultant from different scenarios (Tuominen et al., 2014).

***Transport Modelling***

The choice of the approach adopted to evaluate the scenarios strongly depends on the target of the scenario development or the backcasting approach in general. Transport modelling represents one quantitative tool which has been applied in research that aims to explore different scenarios of transport futures. This tool is valuable in providing insights into the contribution of emissions under different scenarios and the challenges that are faced in reaching the emission reduction targets. There are various types of transport models, with wide-ranging scales of modelling and model outputs. The choice of the model from the wide range of transport modelling approaches depends on the scale, the scope of the analysis and the availability and cost of data required to run the model. Transport modelling approaches, which are used to generate quantitative data about emissions from the sector, can be generally classified into two broad classes namely the bottom-up (or micro) and the top-down (or macro) approaches (Jebaraj et al., 2006). The estimation of emissions from transport using models can be generalized as a two-step approach where travel demand is first determined, followed by the calculation of the related fuel consumption and emissions (Nocera, 2018). The difference between the top-down and bottom-up approaches is in the process by which the emissions are calculated. The top-down approach uses aggregate data on end-use technologies, historical patterns and economic indicators such as income and population to forecast energy efficiency and hence emissions (Daly et al., 2012). On the other hand, bottom-up models are based on a technology description of the transport system and place the emphasis on the correct description on energy options and their cost (Drouet et al., 2005).

Beyond the two-class classification of the top-down and bottom-up models, Linton et al. (2015) have classified modelling approaches used to calculate emissions from transport into six different sets namely; traffic network models; behavioural models; agent-based models; system dynamics modelling; techno-economic models and integrated-assessment models. These models have different temporal and spatial scales which cover the local to the global scale and the short-term to the long-term scales as illustrated in Figure 2.3. The first three sets of modelling can be described as bottom-up while the latter three are top-down models of emission calculations.

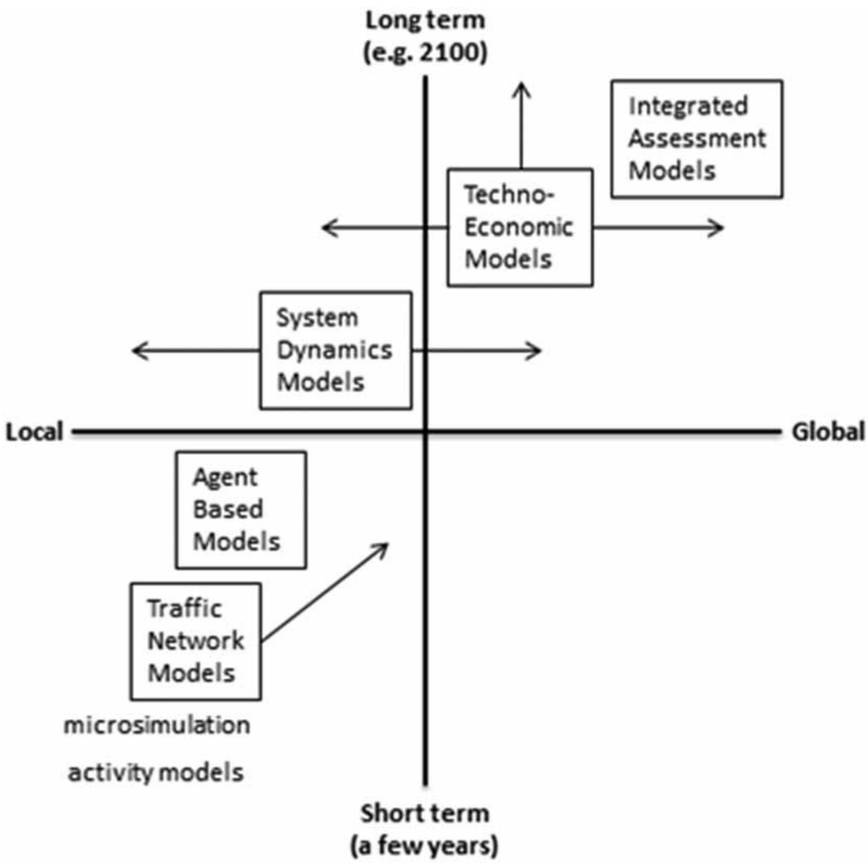



**Figure 2.3: Classification of transport models.**
*Source: Linton et al. (2015)*

Transport network models are a type of bottom-up approach models that rely on microsimulation to model the transport demand and estimate $CO_2$ emissions according to the scenario under analysis. In this type of approach, travel demand modelling is usually based on a four-step process that includes trip generation calculations, trip distribution, mode choice and trip assignment (Fu et al., 2017). The strength of the traffic-network model is in the detailed representation of the technology. However, on the other hand, these models have limited representation of the macro-economic influences from economic system (Marcucci et al., 2012; Tuladhar et al., 2009). Examples of such modeling approaches can be found in the National Transport Model (NTM) for Malta, which has been used extensively during the development of the national transport strategy and master plan (Transport Malta, 2016a, 2016c). For these, an integrated transport analysis was carried out and transport forecasts were computed. The NTM was constructed with the purpose of informing policy on the transport needs and impacts. In addition to the appraisal of transport scenarios and the provision of transport forecasts, the model serves the purpose of producing outputs for more detailed local or project models and as input for engineering design processes, economic and financial analysis, environmental assessment and monitoring of projects. The NTM is also designed to provide outputs in terms of emissions of $CO_2$ and air pollutants. The model was developed around a base year (2014).

Activity-based models draw on social psychology and behavioural economics to predict travel behaviour and model better the demands for transport. This approach takes into consideration additional factors beyond the need to travel such as motivation for travel, the individual's psychological, economic and social needs, household roles, profession, lifestyle and constraints on travel in understanding travel behaviour (Ettema et al., 1993). Activity-based modelling is generally seen as more capable of addressing the behavioural dimension of travel demand and hence offers an improvement over the travel demand models (M. Malayath et al., 2013). This type of modelling requires a high degree of detail and makes the calculations very complex and time consuming. For this reason, their use is mostly suitable for short-term temporal scales and limited spatial scales.

Agent-based models, are another type of bottom-up models which have also seen application in measuring the impact of different policies on the $CO_2$ emissions from transport (for example (Teo et al., 2014). This type of modelling approach acknowledges the fact that the transport system is a very complex one made up of a high number of stakeholders, which are heterogeneous and have different roles, needs and aims. The approach takes individual agents and models their interactions to determine the system-level result (Maggi et al., 2016). Agent-based modelling is used in transport modelling as it is capable of describing complex systems, such as the transport system, based on the behaviour of its basic agents or elements. This type of modelling gives the researcher the advantage of shaping the different agents with heterogeneous behaviour allowing for the observation of emergent properties. Similar to activity-based models, agent-based models often require significant quantities of data that can be computationally intensive, and difficult or costly to obtain (Sanford Bernhardt et al., 2008).

Top-down transport modelling defines another set of modelling approaches and includes amongst others the techno-economic models. Techno-economic models are generally macro-scale models which look into transport as a sub-sector of the wider economic activity (Schäfer, 2013). Such models use socio-economic characteristics and indicators to forecast changes and estimate transport and technology forecasts to allow projections of future emissions (Psaraki (Linton et al., 2015; Psaraki et al., 2012). Integrated Assessment Models (IAMs) are also a type of top-down modelling approach that is commonly used to assess the implications of long-term climate change mitigation policies (Pietzcker et al., 2014). These type of models take into account the relationship between technology, economy and society and transport is taken as one of the subsectors of the economy.

As summarized in Table 2.4, top-down and bottom-up approaches present two sets of approaches for modelling transport and emissions from the sector. On one hand, the top-down approach is suitable for understanding the factors affecting emissions at the wider geographical scale (national or global scale) while providing less detailed information on the individual factors of the system. On the other hand, bottom-up approaches provide detailed information on individual's behavior, choices and interactions between the elements of the system but neglect the influence from other factors operating at the macro-scale.

**Table 2.4: Classification of Transport Models**

| Scale | Type of model | Characteristics | Advantages / Disadvantages |
|---|---|---|---|
| Bottom-up | Traffic network | Microsimulation of the traffic network based on the four-step model | Accurate modelling of the transport system. The modelling approach is complex and takes into account the short to medium term temporal scale |
| | Activity-Based | Travel demand is modelled on the mobility needs which are in turn based on social psychology and behavior | The model is capable of providing information about the transport demand at a good level of accuracy. Limited temporal and geographical scales |
| | Agent-Based | Travel demand is modeled based on the agents behavior, decisions and their interaction with the system | The accuracy of modelled transport data is high. However, such models require high complexity calculations and offer limited temporal and geographical scales. |
| Top-down | Techno-economic | Transport is taken as one of the sub-sectors of the socio-economic and energy system. Transport demand is modeled as a result of the influence from the economy and social structure | Takes into account the effect of economic parameters on transport. Computation of data is simple and the model is capable of providing insights for long-term policies and over a wide geographical scale. |
| | Integrated Assessment | Modeling is based on GDP, population and socio-economic variables which have an influence on the travel demand. | Modelling of transport is integrated with variables based on economic parameters. The model is suitable for the analysis of long-term policies across a wide geographical scale |

*Source: Author's summary based on Linton et al. (2015) and Nocera et al. (2017)*

In between the macro and micro models is another type of transport model using the system dynamics approach. This type of model adopts both qualitative and quantitative techniques to assess the transport demand (Abbas et al., 1994; Shepherd, 2014). The system dynamic modelling approach offers a number of advantages over the other types of transport models and is well-suited to strategic policy analysis and as a support tool for decision making. The main advantage of system dynamics is that this type of approach accounts for the complexity of the transport system which involves different elements and stakeholders interacting together creating feedbacks with different response times. In this way, system dynamics offers a new perspective to transport modelling and serves as a tool for policy makers to understand the dynamic interactions that exists between the different elements and stakeholders (Abbas and Bell, 1994).

System dynamics, is part of the family of systems approaches and provides a systematic understanding of the dynamics of complex systems. These forms of approaches integrate different forms of knowledge and include feedback loops and counterintuitive behavior. System dynamics was developed by Forrester in the 1950s based on system theory, control theory, information science, feedback control theory, military games, tactic decision-making and organizational theory (Abbas et al., 1994). The main principle behind system dynamics is to construct models of complex systems and experiment with different scenarios using computer programs. The modelling technique started to be applied in business management and has also seen application in government policy, healthcare, and the automobile industry (Sterman, 2000).

In system dynamics the casual feedback relations between the different elements of the system are represented in the form of positive or negative feedback loops. The former amplify the process which, without any negative feedback loops with lead to exponential growth. These reinforcing and balancing loops allow for a dynamic equilibrium to be reached. This type of qualitative approach is linked to a quantitative model outputs via stock-flow diagrams. A system dynamics (SD) model can be described as a map of the system's important stock-flow structure, where the stocks and flows are embedded in feedback loops. The approach facilitates quantitative analysis in terms of their behavior and through computer simulation. Modelling based on system dynamics requires the use of software platforms such as VENSIM, which is one of the software used for developing SD models.

System dynamics approaches have been applied to a number of transport problems as a powerful decision-making tool to analyse the effects of future policy scenarios. Shepherd (2014) has provided a literature review of those studies where this type of modelling has been used, and identified a number of examples including the modelling of the uptake of alternate fuel vehicles, supply chain management with transport, construction and maintenance of road infrastructure, aviation and strategic policy analysis. In addition to these examples, system dynamic models have been particularly useful for the study of transport policies which have long-term impacts, such as for example policies aimed at reducing the environmental impacts of transport. Amongst these are also studies that have used system dynamics to assess the effectiveness of policy in reducing $CO_2$ emissions from transport and achieving the climate change mitigation targets.

Modelling approaches struggle to model travel behaviour changes beyond new infrastructure. Behavioural responses to new interventions are difficult to estimate, as much depends on the context and cultural norms, indeed the cultural context frames what is possible to implement in project and strategy terms. Hence alternative tools, combined with scenario analysis are important to help understand potentially radically-different futures

## 2.7 Conclusion

The literature review has shown that there exist a wide range of tools through which the issue of climate change and emissions from transport can be studied. Scenario analysis provides a useful tool for transport planning and climate policy as it allows for an understanding of multiple interlinking social, economic and technological issues. The scenario analysis is useful in exploring alternative futures when the future under the business-as-usual conditions is unsustainable. In particular, the backcasting approach has found application used in the field of transport and climate policy. The approach involves taking a normative view of desirable endpoints in the future, and then examining the means and pathways by which those futures can be reached (Soria-Lara & Banister, 2017). A wide range of methods and analysis techniques are available for use in conjunction with the backcasting approach. The next Chapter will look at the theoretical framework which will be at the basis of the backcasting study for this research.

# CHAPTER 3: THEORETICAL FRAMEWORK AND RESEARCH GAP

This section introduces the theoretical framework that underpins the research study. This study is based on the Theory of Social Practice, which frames the research. The framework upon which the study is designed guides the choice of methods for data collection, design of analytical tools for data analysis and helps to place the research in the context of the wider literature.

## 3.1 Theory of Social Practice

### 3.1.1 Contemporary Practice Theory

Practice theory presents an alternative and distinctive approach towards understanding society. In this alternative approach, which has been classified as a cultural theory (Reckwitz, 2002a), practices are the fundamental and smallest unit of social analysis. Contemporary commentators to practice theory agree that there is no coherent and unified Theory of Social Practice but rather a body of diverse writing and thinking in social sciences (Schatzki, 1997; 2001; Reckwitz, 2002). Practice theories have emerged as a set of theories with cultural, philosophical, social and science and technology influences and which theories focus on the conditions surrounding the practical carrying out of social life (Reckwitz, 2002a). The major driving force underlying these theories has been the impulse to move the social science disciplines beyond the problematic dualisms of the traditional ways of thinking.

The first initiatives in seeking an alternative for the limitations of the traditional social theories can be found within the social scientific work of Bourdieu (1977) and his publication of *Outline of a Theory of Practice.* The theory has been classified as a Grand Theory – an abstract and normative theory of human nature and conduct that is generic and that can be applied to different circumstances and areas of research (Reckwitz, 2003; Skinner, 1990). One major contribution of the work by Bourdieu is the reconciliation of the dualism of structure and agency where on one hand social structures act as rules and condition the individual’s behaviour, while the agency perspective suggests that the individuals are completely free in their choices. Bourdieu conceptualises the daily life of social agents as determined by an infinite amount of interactions that take place within their respective social space, which in turn is subdivided into different social fields. Within these social fields, the agents and instructions are integrated and interact with each other in accordance to field-specific rules. Fields can thus be described as places of power relations where the practices of agents are not arbitrary and that all interactions are anchored in a specific social field. In order to be able to obtain the right to enter a social field, agents need to be endowed with specific resources or capital (Bourdieu, 1977). While four types of capital namely economic, cultural, social and symbolic have been distinguished, each field values particular sorts of capital with four types of capital namely, and each type can be exchanged against others (Bourdieu, 1977). The capital structure also determines an agent's position on the field.

The concept of *habitus* has also been central in Bourdieu's theory. Habitus is the *strategy generating principle enabling agents to cope with unforeseen and ever-changing situations* (Bourdieu, 1977). The habitus ensures that agents act in accordance with the field specific rules. The interplay of field, capital and habitus lead to strategy or practice.

On the same lines as Bourdieu, Giddens (1984), in his structuration theory has also emphasised the need to move away from the agency-structure dualism of sociological studies. The concept of structuration aims to bring together the human agency and social structure and also introduces the possibility of structural change. As other practice theorists, Giddens aims to bridge the gap in the dualisms between voluntarism and determinism, individualism and structuralism and micro and macro through the notion of practice. For Giddens, practices extend themselves by continuously renewing the conditions that determine them. This theorist defines social practice as an *ongoing series of practical activities* (Giddens, 1984). These activities, which are reproduced over time, bring together the individual and the structure. Furthermore, Giddens stipulates that a practice is a nexus of actions and that the renewal of structure comes about through the actions that compose them. The structure governing practices has been described as composed of rules and resources with rules being generalizable procedures of actions implicated in the practical activities of daily life. On the other hand, resources are the medium through which social power (or the capacity to bring about changes) is exercised (Giddens, 1979; 1984). Together, rules and resources secure the space-time extension of practices.

Michel Foucault, has experimented with a number of different theoretical options, especially during his earlier work (1960s to 1970s) and which ranged between structuralism, post-structuralism and a Nietzschean theory of the body (Reckwitz, 2002). Later in his work, the theorist developed the idea of *discipline* (Foucault, 1979), which is also closely related to the Bourdieu's notion of habitus, and which has been influential in the development of the Theory of Social Practice. Through this idea, the theorist describes how the constitution of present day-activity centrally consist in the fashioning of bodies with disciplinary practices. Similarly to the other commentators on practices and as well noted by Sewell (Sewell Jr, 1985), Foucault has contributed to shifting the emphasis from the highly self-conscious purposive individuals attempting to enact blueprints for change to the relatively anonymous and impersonal operation of ideological state apparatuses, epistemes, cultural systems or structures of feelings.

Building on the early concepts of practice theories, contemporary practice theorists have continued to developed the idea of practices by emphasising on the centrality of the human nature and at the same time paying attention to the important social processes. New concepts in this discipline have continued to be developed and practice theory has had many new applications in different areas of the social life (Postill, 2010).

### 3.1.2 Practice theory as a Cultural Theory

As already emphasised in the previous section that illustrated the historical development of the theory, practice theory presents an alternative and distinctive approach towards understanding society. In this alternative approach, practices are the fundamental and smallest unit of social analysis. To understand the usefulness of practice theory and visualise the opportunities offered by this approach, it is important to distinguish this approach from other theories that study social phenomena (Halkier et al., 2011). Reckwitz (2002a) in attempt to give a more stable and unified identity of practice theory, mapped the theoretical concept behind the theory and identified the distinctiveness and the uniqueness of the practice theory.

His work in the field has been critical amongst others to frame and position practice theory in relation to other forms of social theory. In the words of this theorist, practice theory, offers a system of interpretation, a conceptual framework that comprises a certain way of seeing and analysing social phenomena, which enables certain empirical statements and excludes others (Reckwitz, 2002a). In the theorist's perspective, social theories can be classified in three types;

the purpose-oriented theories (homo economicus), norm-oriented theories (homo sociologicus) and cultural theories. In purpose-oriented theories, social behaviour is explained in terms of the individual and the smallest unit of analysis is human action. On the other hand, when dealing with norm-oriented theories, human behaviour is explained through societal norms and structures with the unit of analysis being normative structures (e.g. values and social rules). Cultural theories (which also include culturalism, mentalism, textualism and intersubjectivism) represent a distinct class of theories that reject the dichotomy that exists between the purpose-oriented and purpose-oriented theories, and analysis the social as the collective symbolic structure.

This position of practice theory within the social theory (Figure 3.1) is important for understanding practice theory. Taking a practice theory approach therefore means that neither the individual nor the norm structures are ignored. As Schatzki (2001) puts it, practice theory offers a conceptual framework that gives a *general and abstract* account of the topic of study. Despite the general agreement on the positioning of practice theories in social science and on practices as the basic unit of analysis, practice theory does not offer a *systemised* vocabulary (Reckwitz, 2002a) as with other theories. Building on the early concepts of practice theories, contemporary practice theorists have continued to develop the idea of practices by emphasising on the centrality of the human nature and at the same time paying attention to the important social processes.

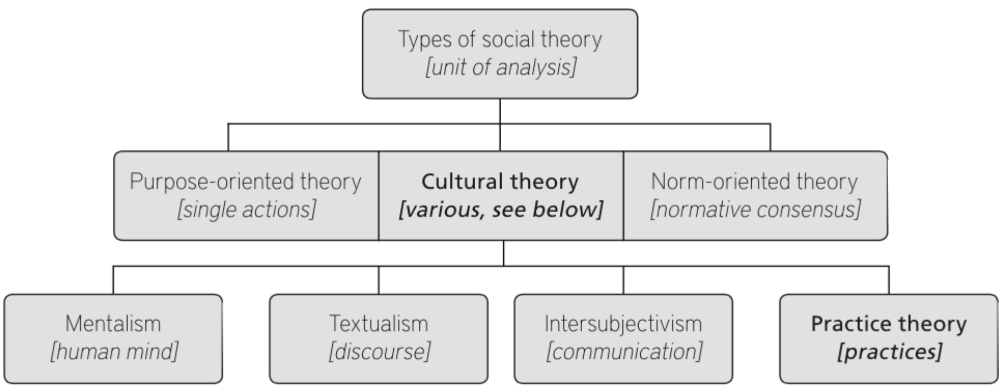



**Figure 3.1: The position of practice theory within social theory**
*Source: based on Reckwitz (2002) and as illustrated by Kuijer (2014)*

### 3.1.3 Elements of Practice

Various theorists in social practice have defined what constitutes a practice. According to Schatzki (2002), for example practices are *spatially-temporally dispersed, open sets of doings and sayings organised by common understandings, teleologies, and rules.* Another definition, which is widely cited amongst practice theory users, is that by Reckwitz (2002). In defining practices, he first distinguishes between practice (or *Praxis*) and practices (or *Praktiken*). The former represents an emphatic term to describe the whole of human action. On the other hand, a practice (*Praktik*) according to Reckwitz is:

*…a routinized type of behaviour which consist of several elements, interconnected to one other: forms of bodily activities, forms of mental activities, 'things' and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.*

In their definition of practice, both theorists agree that practices do not exist as single entities, rather they are constituted from a number of elements. For Schatzki (2002), common understandings, teleologies and rules are the elements that shape and organise practices. Contrastingly, Reckwitz (2002) identifies at least seven elements of a practice (body, mind, things, knowledge, discourse, structure/process and the agent/individual).

More recent scholars in the theory of practice, subscribe to different descriptions of the elements of practice. Spaargaren (2011) takes a macro-perspective of social practices and emphasise how practices are shaped by the interplay between structure and agency. This idea of practices contrasts with other theorists' ideas that look into practices as dynamic entities. For example according to Warde (2005) understandings, procedures, engagements and items of consumption are the elements that make up a practice. Shove and her colleagues (Shove and Pantzar, 2005; Shove et al., 2012) apply a different terminology to the elements of practices as they deconstruct practices into three elements namely competences, meanings and materials or alternatively skills, images and stuff. Similarly, Hargreaves (2011), describes practices as being made of three distinct elements. In this view, images (meanings, symbols), skills (forms of competence, procedures) and stuff (materials, technology) are dynamically integrated by skilled practitioners through regular and repeated performance. Whilst variances exist on the configurations of the elements of practice, commonalities can be found in the ways the consistent components of practices are defined. Some studies (Gram-Hanssen, 2011) draw on the work by Reckwitz (2002) and describe practices as composed of know-how and embodied habits; institutional knowledge; engagements; and technologies. Similarly, innovation in practices may be analysed as composed of devices or artefacts applied, the physical and institutional infrastructure, and in user practices involving learning and behaviour (Brezet et al., 2001). Most studies that focus on investigating the transitions in everyday life for example (Cass et al., 2016; Kuijer et al., 2013; Scott et al., 2009; Spotswood et al., 2015) are based on the three-element model approach by Shove et al. (2012) which model remains the most utilised in research analysing transitions in everyday life (Figure 3.2).

Materials in the three-element system include objects, infrastructures, tools, hardware and the body itself (Shove et al., 2012). In this description of the materials there is no distinction between humans and things. Materials or stuff are *directly implicated in the conduct and reproduction of daily life* (Shove et al., 2012). Furthermore, these materials only have value when *integrated into practice and allied to requisite forms of competence and meaning* (Shove and Pantzar, 2005).

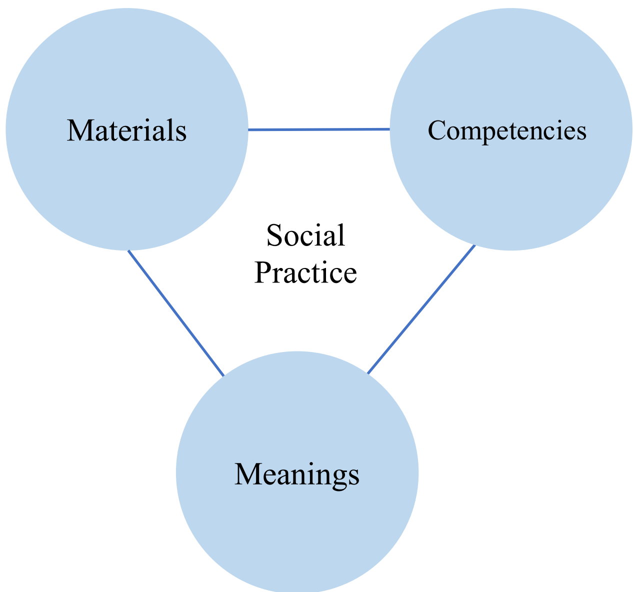



**Figure 3.2: Three-Element Social Practice Framework**
*Source: Shove et al., (2012)*

Meanings or images are socially shared ideas or concepts within a practice that gives meaning to it and reasons for engaging in the practice. Meanings are often based on concepts of association, relative positioning, norms, values and ideologies (Shove and Pantzar, 2005). As Shove et al. (2012) further explain *theories of practice emphasize tacit and unconscious forms of knowledge and experience through which shared ways of understanding and being in the world are established.* Meaning in the sense of practice theory may also refer to fitting or rightness of a practice, where a practice can be considered right based on the significance of the number of practitioners routinely performing the practice (Spotswood et al., 2015).

Competences or skills on the other hand refer to the *multiple forms of understanding and knowledgeability* (Shove et al., 2012). They include learned bodily and mental routines, know-how, levels of competence and ways of feeling and doing. Reflecting on earlier ideas by Schatzki (2001), skills in the framework of practice does not only include knowing how to act appropriately, but also knowing how to talk about, how to recognise and how to prompt and respond to such actions. Skills involve knowledge about what is good, normal, acceptable and appropriate (and what is not) and learned, bodily/mental competence to reach these standards.

### 3.1.4 The role of people in practices

While the individuals are not the central unit of analysis in practice theory, they play an important role as the carriers of practice. Reckwitz (2002) identifies the role of people as body/minds who carry and carry out social practices as is emphasised in definition of practice as *routinized bodily activities.* Through routinized performance of the practice, the body/mind becomes trained in the practice and knowledge about the practice becomes embodied in the practitioner.

In a practice-oriented approach, people are analysed as the carriers and performers of practices. While people are an important element of the practice-as-entity, they are also crucial to performance and continuity of a practice. People are key for changes in practice by adapting, improvising and experimenting in changing circumstances of everyday life (Warde, 2005).

In the explanation by Shove and Pantzar (2005), people and practices have careers and *the careers of individual practitioners determine the fate and future of the practice itself. As more or different people become involved so the meaning and experience of involvement changes and so the practice evolves*. In this view, practices over the course of their career are carried out by changing groups of differently skilled practitioners.

For practices to exist they need to be performed by a group of people and practitioners can be recruited into a practice and with repeated performance, become experts in the practice they perform (Shove et al., 2012). Different practitioners with different levels of competences, skills, ideas and commitment can be recruited in the practice (Warde, 2005).

### 3.1.5 Bundles and Complexes of Practices

Schatzki (2002) further emphasis that individual practices do not exist as single entities, rather practices are connected and influenced by other practices. He also argues that bundles of practices and material arrangements make up sites of the social (Schatzki, 2002). Practices are bundled together through various ways and complexes of practices are formed when individuals are the carriers of more than one practice. Practices also interact when they take place in the same location or in sequence to each other. Things and material objects through their persistence in space and time connect both different practices but also different performances of the same practices. Other than things, skills and meanings also play a role in binding different practices together, for example, meanings of cleanliness connect practices such as laundering and bathing (Shove, 2003).

Shove et al. (2012), identify at least two ways in which practices can be related. Practices can be bundled together through co-existence or through co-dependence. Links between the different practices or performance of practices can be said to consist *of webs of co-dependence that are not evenly arranged (but include knots, nodes, relays, etc.) continually rewoven as practices are reproduced* (Shove et al. 2012).

When different practices interact, they influence each other and as Warde (2005) explains; *lessons are learned, innovations borrowed and procedures copied.* A change in one practice therefore can have an effect on other practices which co-exist with or is dependant co-dependant on the practice undergoing a transformation. A good example to illustrate how practices influence each other is by looking at the practice of storing food. With the introduction of the freezer (an element of practice), the way in which food is stored changed and consequently co-existent and co-dependent practices such as cooking, eating and shopping also underwent a transformation. Practices are also known to compete for limited resources such as space and time.

From a social practices perspective, the lifestyle of an individual can be conceptualised and be composed of an assemblage of social practices such as working, parenting, cooking, eating, travel and leisure. Together these *represent a particular way of life and give substance to an individual's on-going narrative of self-identity and self actualisation* (Evans et al., 2009).

### 3.1.6 Application of Theory of Social Practice to sustainability transitions

Within practice theory there are various concepts for analysing how practices change through time and how innovation in practice occurs. Shove (2007) state that practice innovation occurs due to changes in the tools we use (materiality), how we use them (technical know-how), and when and why we carry out a practice (cultural meaning). This can be observed for example in the way new meanings for freshness and comfort have shaped the practices of eating and washing. Other studies emphasise the importance of the re-organisation of infrastructure and systems of provision in changing daily practices (Chappells et al., 2000; Rubik et al., 2009; Spaargaren, 2003). The challenge of changing routine social practices requires a more holistic or systemic perspective, that brings into focus the interplay between different elements and to the broader sociotechnical system within which practices are situated.

The social practice model differs from other behavioural approaches in several ways. First, theories of practice decentralise the individual and make behavioural practices at the centre of the analysis (Collins, 2004). Second, the focus is not on specific and isolated behavioural items but is based on a designated group of actors and their potential in reducing the environmental impact of their normal daily routines. Third, social practices analyses transitions to sustainable lifestyles in distinct domains of social life, thus bringing social structures at the centre of the analysis rather than being treated as external variables (Spaargaren, 2003).

The application of theories of practice to research in sustainability is only recent and it is more common within academia rather than the commercial sector or in policy development. The role of social practices and in informing sustainable change innovations is gaining momentum. Most work based on a social practice approach has been done in environmental debates on socio-technical transitions, design change and sustainable consumption (Hoolohan et al., 2020; Kuijer et al., 2015; Scott et al., 2012; Vihalemm et al., 2016; Walker et al., 2007). For example, Kuijer et al. (2012) have applied practice theory to study thermal comfort. Similarly, Scott et al. (2009) used the practice based approach to investigate new routes for innovation in washing. This study led to the discovery of the qualities of bathing that could be re-configured to more innovated forms of this practice. Other studies have used the Theory of Social Practice to provide insights that could aid with the reduction of food waste (Castelo et al., 2021; Keegan et al., 2021). Whilst a growing body of practice-theoretical work has focused on energy and innovations in this field (Rau et al., 2020; Sahakian et al., 2020; Torriti, 2017). In the UK, especially, work in the lines of practice theories and sustainability has been pioneered by Shove et al., (2007; 2012).

Applications of practice theories to the study of sustainable mobility are focused on understanding how practices have evolved, the elements that make up these practices and how practices are embedded in everyday life (Shove et al., 2012). Such an understanding helps to reveal how some forms of mobility practices become prevalent whilst others are less successful into becoming embedded in the daily life (Shove et al., 2012; Watson, 2012). Shove and Walker (2010), use the Theory of Social Practice to study the case of congestion charging in London, where they identify how the movements of people and objects around are a consequence of the spatial-temporal demands and the integration of constitutive elements of different social practices and the interaction of these practices with each other. The instances of movement are also a consequence of the socio-technical fabric of means, modes and timings. The study demonstrated how a policy action, such as congestion charging, can influence different practices, their complex interaction and the flow of materials causing reconfigurations and self-organisation of practices.

The application of practice theories to guide policies and interventions is gaining popularity amongst researchers, one such example is the empirical case of car sharing in Sydney, Australia (Dowling et al., 2015; Kent et al., 2013), which focuses on the exploration of modal shift from car to car-sharing forms of mobility from the perspective of social practice. The research served to demonstrate how such a form of mobility can be understood through the characterisation of a distinctive assemblage of materials, meanings and skills. The success of car-sharing (as an innovative practice) is possible through the reconfiguration of existing elements in new different ways. The analysis from a social practice point of view also highlights the direction that policy-makers should take to aid transitions towards less carbon-intensive and more sustainable practices. The approach hints at policy-makers to focus on influencing the constitute elements of a practice if the shift to different practices is to be made more productive

(Shove et al., 2012). Interventions should also be made at the institutional and infrastructural levels which are known to hold different practices together (Kent and Dowling, 2013).

Spurling et al. (2013) have proposed a framework to guide policy interventions on how to use a practice approach to achieve transition to sustainability. While identifying the pitfalls and gaps in the current policy approaches (which rely on technological innovation, and changing of consumer choices and individual behaviours), the report identifies three different framings based on a practice approach. One such framings – the re-crafting practices framing – aims at reducing the resource-intensity of existing practices through changing the elements that make up those practices. The framing suggests a more systematic approach to interventions. This can be achieved by identifying how elements can be combined in less resource intensive performances and setting up interventions to shift elements or replace elements with ones that allow for more sustainable practices. Substitution of unsustainable practices with new alternatives is another policy framing proposed by Spurling et al. (2013). Two alternative methods can be explored to achieve substitution, namely by focusing on competition between practices or by encouraging more sustainable variants of a practice. A third alternative to the practice approach to policy interventions lies in changing how different practices interlock. From the work by Shove et al. (2012) it has been identified that such interlock can be achieved either through synchronisation of practices or sequences of practices. Policy interventions based on a practice approach can thus be focused to change the way how practices are synchronised or re-ordering the sequencing of connected practices.

A practice perspective has important consequences for policy interventions. The key innovation in this approach is to identify unsustainable practices and focus on how these practices can be substituted. The concept of interlocking practices also suggests intervention in other policy areas if a transition to sustainable mobility is to be achieved. Other than implications for policy, a practice approach to sustainable mobility presents epistemological challenges in transport research that deals with climate change mitigation. Since the approach is innovative and different from other approaches adopted in transport research, new methods for data generation and modes of analysis must be sought to accommodate the practice perspective.

Empirical studies using qualitative data and mobility biographies have been at the basis of the analysis of mobility practices and the shift to lower-carbon travel alternatives (Cass et al., 2016; Kent et al., 2017; Franziska Meinherz et al., 2020; Rau et al., 2018; Uteng et al., 2019). (Cass et al., 2016) for example use the theoretical approach to understand the barriers to modal shift from car to low-carbon forms of transport in commuting. Their finding suggest how policy can intervene to address the missing elements of low-carbon communing and how interventions in other areas of the social life can influence the modal shift. Through their analysis based on the Theory of Social Practice, Kent et al. (2017) find that modal shifts can be catalysed by disruptions in every-day life or through the re-ordering of existing mobility practices. They also show how willingness, ability in navigating new practices and infrastructure are also essential for the shift to more sustainable forms of mobility. (Uteng et al., 2019) adopt a practice theory and mobility biographies research for capturing the heterogeneity of mobility practices and the micro-dynamics of adoption and retention processes at different life stages. They highlight how practice theory's biggest potential contribution is in highlighting and explaining user adoption of innovations as a process of recruitment and retention that results in the integration and reproduction of new practices that replace old ones. (Rau et al., 2018) examine biographical aspects of people's everyday mobility that capture and reflect their social relations for uncovering the dynamics of mobility practices across the life course. The findings suggest that social relations play a key role in holding mobility practices together, and that shifts in social relations and roles can have implications for mobility practices.

## 3.2 Research Gap

Transport research plays an important role in addressing the climate change mitigation challenge given the significant contribution of this sector to the total fossil fuel use and related global GHG emissions (Chapman, 2007). Road transport has emerged as the greatest contributor to global warming and pose a great challenge towards the achievement of the agreed world 2°C mitigation target (Li, 2011). Transport research has in many ways analysed the potential of emission reduction from the sector yet the academic literature is dominated by approaches that focus on mitigation via technology or insights from neo-classical economics and travel behaviour (Schwanen et al., 2011).

These dominant approaches, while offering valuable insights into understanding how transitions to lower-carbon mobility can be achieved, do not come without limitations (Geels et al., 2018). At the same time, it has been recognised that transport research could benefit from the integration of multiple perspectives that would help in understanding the complexities of modern mobility (Pangbourne et al., 2011). In this context, one perspective that could contribute to enhance the understanding of climate change mitigation from transport is the social science perspective (Dennis et al., 2009; Yearley, 2009). Social sciences could be of benefit to transport research in a number of ways, such as opening up to insights on how transport is embedded in social processes, by providing a wider choice of research methods and allowing for alternative research questions (Schwanen et al., 2011). Despite this recognition of the benefits of social sciences, studies on climate change mitigation from the social sciences are still limited in academic literature on transport. This is the first gap in research that needs to be addressed.

Previous sections in this Chapter has demonstrated how the Theory of Social Practice by Shove et al. (2012) is one framework that could be applied in transport research for understanding how a shift toward more sustainable forms of social life could be achieved. A number of empirical studies in transport research have adopted the social practices approach as their theoretical framework. Amongst these are the ones which have sought to study the adoption of cycling as a mobility practice (Spotswood et al., 2015), investigated a transition in commuting practices (Kent, 2013;) and analysed the dependency of a range of activities on the use of the car (Mattioli et al., 2016).

Research on the application of practice theory to guide policies and interventions for sustainable transport is still being developed and is non-exhaustive. Furthermore, many of the studies based on a social practices approach have focused on modal shift or analysed how policy could intervene in one practice transport (cycling for example or car sharing). Others have looked at one policy approach that could bring about a shift to low carbon mobility. Cass and Faulconbridge (2016) on the other hand have looked at different types of mobility practices, yet their study was limited to the commute (Cass et al., 2016). Hence, this suggests that more research is needed that looks at the broader picture of transport practices in relation to how these are embedded in the social processes and how changes in such practices can contribute to lower the emissions from transport. Against this background, this research will seek to understand the current mobility practices, how these are connected to other social practices and how alternative policy options can reconfigure such practices into less carbon intensive forms. This research will thus be building on the knowledge and adding to the current literature on social practices approach in transport research. This research therefore introduces innovations from the theoretical perspective by applying the Theory of Social Practice to develop policies and policy pathways towards low carbon mobility.

Furthermore, from the review of literature on transport research using practice theory it can be observed that to date, studies have been limited to identifying the elements of a given practice, or how practices interact with other practices. Such findings would then be used to make recommendations on how policy could intervene to reconfigure the elements of the practices and make them more sustainable. On the other hand, it has been recognized that little research has been conducted into generating and evaluating alternative practice configurations (Kuijer and De Jong, 2012). This observation points to a second gap in research, where alternative practice reconfigurations can be designed and evaluated in terms of their potential to reaching sustainability targets. This gap has already started to be addressed in some research areas on sustainable transitions. For example, a social practices approach has been integrated with backcasting technique to identify the effectiveness of alternative practice configurations and design policy pathways through which such reconfiguration can be achieved (Doyle et al., 2013). This integration with a backcasting technique represents a methodological innovation in social practices based approaches. To the researcher's knowledge, this method of using a practice based approach with backcasting has not found its application in transport. Hence this study will build up on this emerging research direction and contribute to the body of literature that apply the Theory of Social Practice in sustainable transport.

This study employs a backcasting approach to transfer perspectives based on the Theory of Social Practice into policy pathways that can contribute to lowering emissions from the transport sector. With this study it is hoped that new insights for transitions to low carbon mobility in the context of the case study are developed. The research also aims to contribute to the wider literature on transport research and climate change mitigation.

Backcasting has been shown to be a valuable tool in the field of transport and climate policy. The technique is known to be useful in looking at preferred futures over the long-term and design policies which break the current and unsustainable trends. One issue with the use of backcasting in transport planning arises because such methods of policy making still harbour the characteristic of expert-led processes with strong hierarchal power between the researcher and other stakeholders (Banister, 2008; Schwanen et al., 2011). This lack of communication creates a barrier in policy making in the way by which scientific research is translated into policy actions (Banister et al., 2013). Participatory methods have been shown to provide the means of overcoming such barriers (Soria-Lara et al., 2017b). In this context, this study will adopt a participatory backcasting approach adding to transport research that aims to shift transport policy making from a scientific rational form to one based on consensus seeking discussion (Willson, 2001). The use of participatory backcasting will also serve to show how a form of environmental policy making that includes social learning and interdisciplinary perspectives can be applied to transport research (Dreborg, 1996).

Another innovation that this research will present is the case study which looks into the potential of climate change mitigation in Malta. Despite the role that transport plays in the emissions of $CO_2$ and other GHG gases, little research has been done in Malta to evaluate how effective policies and policy pathways could be developed to mitigate climate change. Most of the work in the field has been carried out as part of the development of the National Transport Strategy (Transport Malta, 2016a) and Master Plan (Transport Malta, 2016c). This exercise resulted in the listing of measures that could shift transport in Malta towards more sustainable forms. While short-term, medium-term and long-term measures have been identified, there has been no clear pathways or time frames for implementation of such measures. The application of backcasting technique to transport planning in the Maltese Islands is thus innovative. In this context, the study will contribute towards recommendations for climate policy in transport in Malta and enhance the knowledge on effective pathways for policy implementation. The conclusions and results of this study can also be transferable to other countries particularly those with similar characteristics to Malta.

In addition to the contribution of this research towards the national transport strategy, this study will serve as an important input in other policy areas. In 2021, Malta's Low Carbon Development Strategy was launched with the aim of mitigating climate change in the islands and meeting the country's GHG emission targets (Ministry for the Environment Climate Change and Planning, 2021). The strategy has identified transport as one of the key areas for intervention. Despite the acknowledgment of the importance of the sector in climate change mitigation, to date the strategy has not been specific on how low carbon development will be achieved. Therefore, more research at the national level on the challenges of sustainability in transport particularly in terms of climate change mitigation targets is needed. In this context, this study will serve as a policy instrument in developing low carbon mobility and contribute towards the islands' Low Carbon Development Strategy.

## 3.3 Conclusion

This Chapter has provided an understanding of the key concepts of the Theory of Social Practice which is the theoretical framework behind the study. The theory can be described as a set of diverse ideas and concepts that provide an alternative to the classical approaches for studying social phenomena. Despite the diversity, a number of common concepts that shape the theoretical framework exist. In principle, theorists in practice based approaches agree that practices are positioned within the cultural theories and that a practice consists of an interconnected group of elements. Individuals in practice theory are not the unit of analysis yet they play an important role as the carriers of practices. Different practices are linked together forming complexes or bundles of practices. Practices can be linked either through the people performing the practices, common elements and through the sequence with which different practices are performed.

This chapter was also focused on the research gaps that this study seeks to address. It recognises how transport research that deals with climate change mitigation can benefit from the input of new theoretical perspectives such as the Theory of Social Practice. This research aims to contribute to the literature on how mobility is embedded in the social life and how theories of practices may inform policy aimed at bringing about a transition to more sustainable mobility. The study is based on Malta as a case study which presents a context where the dependence on the private car is high. The case study also offers an opportunity to test the theoretical framework in an island state which presents a different setting than the contexts of the studies found in literature so far.

The next chapter, Chapter 4, will provide a discussion on the research design which was adopted for this study. The next chapter will present the research questions, and the methods used for data collection and analysis.

# CHAPTER 4: RESEARCH DESIGN AND METHODS

Chapter 1 introduced the research problem and presented the context in which the research problem is analysed. It also defined the need for conducting this type of research and defined the aim and objectives of the study. The following chapter (Chapter 2) focused on the review of the literature dealing with climate change mitigation and transport. This served to place this study in the context of the wider literature on the topic and find a suitable approach to frame the research problem. The theoretical framework that underpins the study, the research gap, and the potential contribution of this study to the literature dealing with climate change mitigation and transport were outlined in Chapter 3.

This chapter presents the research design of the study and the methods employed to answer the research questions. Section 4.1 describes the research design and how different methods will be employed to meet the different objectives of the research. Section 4.2 then describes the research agenda and how the key objectives are linked with the research questions and methods for data collection and analysis. Section 4.3 delves more into the research questions and introduces the methods through which each question will be answered. This leads to Section 4.4 which provides the details of the empirical study which describes the data collection strategies. Section 4.5 then outlines the tools and methods used to analyse the data collected during the different phases of the study. The final section (Section 4.6) then concludes this chapter and sets the ground for the next chapter which presents the results of the study.

## 4.1 Research Design

As outlined in Section 1.6, the aim of the study is to analyse how a shift towards sustainable mobility can help in achieving the climate change mitigation targets. The review of the literature and theoretical framework were the first stage of contextualising the research project and that enabled the appropriate research design and methods to be developed. It provided the basis for research design and justification of the choice of methods.

The study aims to address two gaps in research. The first gap relates to the lack of social science perspective in climate and transport research while the second gap deals with how alternative practices reconfigurations can be designed and evaluated. In addressing these research gaps, a research design, shown in Table 4.1, has been formulated. The design, which lists the objectives of the study and the methods utilized to achieve these objectives is guided by the overall aim of the research, the underlying objectives and the theoretical framework as will be discussed in the sections that follow.

**Table 4.1: Research Design**

<table>
<tr><td>Aim:</td><td colspan="2">To analyse how a transition towards sustainable mobility can help in achieving the climate change mitigation targets for Malta</td></tr>
<tr><th colspan="2">Objectives</th><th>Methods</th></tr>
<tr><td>1</td><td>To identify the key approaches in transport research in climate change mitigation and frame a suitable approach for this study</td><td>Theoretical Study: Literature Review</td></tr>
<tr><td>2</td><td>To identify the current mobility practices and how changes in the current practices can contribute towards more sustainable mobility</td><td rowspan="2">Empirical Study:<br><br>Backcasting approach which is a multi-phase process for developing a set of policy pathways which could potentially bring about transition to sustainable mobility and help achieve the climate change mitigation targets.</td></tr>
<tr><td>3</td><td>To determine the impacts of transitions towards sustainable mobility and identify alternative mobility pathways</td></tr>
</table>

## 4.2 Research Agenda

The objectives outlined in Table 4.1, are linked to the methods of the research through the formulation of a number of research questions. This provides the structure of the research agenda which is illustrated in Figure 4.1.

The research agenda shows how the objectives of the research are translated into research questions. Furthermore, it also provides an overview of the choice of methods that are employed to answer each of the research questions. The agenda presented in Figure 4.1 demonstrates how the first objective of the research is met through a theoretical approach where a literature review was carried out to frame a suitable approach for a study on climate change mitigation from transport in Malta. Once a suitable framework was identified, an empirical study was designed that builds on the results of the first objective and which aims to address the second and third objective of the research. The empirical study then aims to answer the second, third and fourth questions of the research. The research agenda is useful to illustrate how the empirical study is a multi-phase process where the different phases answer different research questions. One can also note how the different phases build up on each other and are linked throughout the whole process of the empirical research. This will be further elaborated under section 4.4 below.

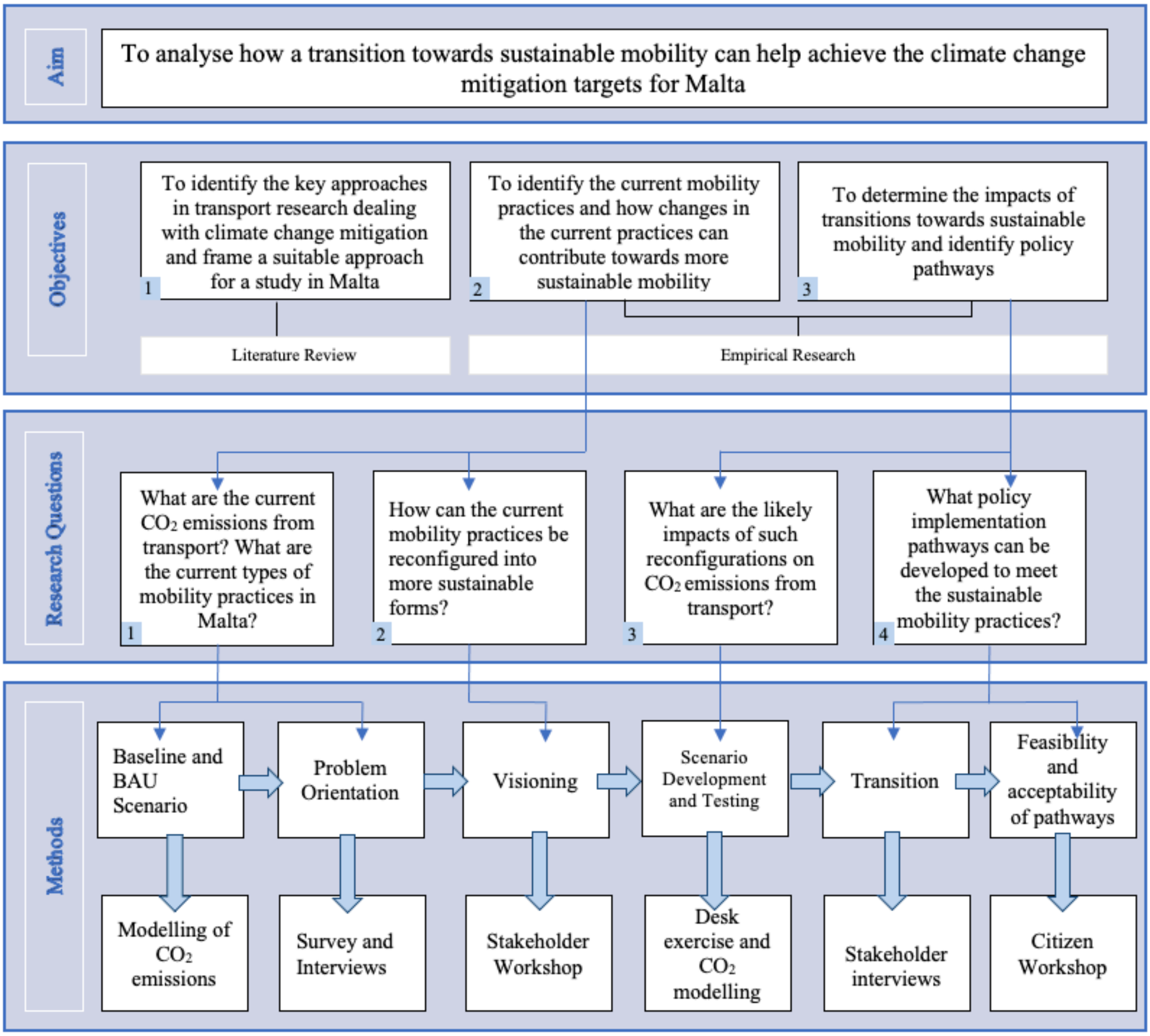



**Figure 4.1: Research Agenda**

## 4.3 Research Questions

The first objective of the research, which involved the identification of a suitable approach for analysing the potential transition to sustainable mobility for the case study of Malta was met through the literature review. The literature review was important to provide an in-depth overview of the current approaches in transport research and climate change and was critical to identify the most suited approach for this study. The Theory of Social Practice and backcasting approach were identified as a suitable theoretical framework for the research. This framework, which was presented in Chapter 3, guided the formulation of the research questions.

The first research question seeks to quantify the current $CO_2$ emissions and identify the current mobility practices for the case study. Research question 2 then aims to explore how the current mobility practices can be reconfigured to more sustainable forms of mobility. The third question aims to understand the emission reduction potential of these reconfigurations. The fourth and last research question then seeks to understand what policy pathways can be implemented to meet the sustainable mobility practices.

The research questions guided the data collection and data analysis methods. These methods are summarised in Table 4.2 and are further elaborated in Section 4.4 which follows.

**Table 4.2: Summary of the research questions and methods of data collection and analysis**

| Research Question | | Research Methods | |
|---|---|---|---|
| | | **Data Collection** | **Data Analysis** |
| RQ 1 | What are the current types of mobility practices in Malta? What are the current $CO_2$ emissions from transport? | - Secondary data on factors which influence $CO_2$ emissions<br>- Survey with 400 respondents<br>- Semi-structured interviews | - Modelling $CO_2$ emissions with a pre-defined model<br>- Statistical Analysis of the survey data<br>- Thematic analysis of the interview data. |
| RQ 2 | How can the current mobility practices be reconfigured to more sustainable forms? | - Stakeholder Visioning workshop | - Clustering and elaboration of the statements<br>- Desk exercise to develop future transport scenarios |
| RQ 3 | What are the likely impacts of such reconfigurations on the $CO_2$ emission from transport? | - Secondary data on factors which influence $CO_2$ emissions | - Modelling $CO_2$ emissions under different transport scenarios<br>- Comparative analysis for different visions |
| RQ 4 | What policy implementation pathways can be developed to meet the sustainable mobility practices? | - Transition survey and semi-structured interviews with experts<br>- Citizen Workshop | - Thematic analysis of the interview and workshop data<br>- Desk exercise to develop policy pathways |

## 4.4 Empirical Study

### 4.4.1 Case Study Approach

Case study approaches have been applied across a wide range of different disciplines especially in the social sciences. It is generally agreed that such an approach is very useful to obtain an in-depth investigation and multi-faceted understanding of a problem, event of phenomenon of interest within its real-life context (Stake, 1995; Yin, 2003). There have been various definitions as to what constitutes a case study (for a comparison of different definitions see Crowe, (2011), however a central theme is the exploration of a given event or phenomenon in its natural context. The approach is considered to offer a number of advantages including the understanding of correlations which might not be mined using other approaches, use of multiple data collection methods and opening up of possibilities for new inquires. Case study approaches, in contrast to experimental designs that aim to test hypothesis by altering the environment, tend to look more into explanatory *how*, *what* and *why* questions.

Stake (1995) characterised three main types of case studies namely; intrinsic, instrumental and collective. An intrinsic case takes one phenomenon and focuses on its uniqueness. In such approach, the uniqueness of the phenomenon must be well defined and the case distinguished from all others. On the other hand, the instrumental approach uses a particular case to seek a broader understanding of the phenomenon. The collective approach involves further analysis of multiple cases to generate a broader appreciation of the phenomena and make generalisations on a particular issue. As Crowe et al. (2011) note, the different types of case studies are not necessarily mutually exclusive and one case study could prove to have properties of different types of case studies. For example, a case study could start of as an intrinsic case study because of its uniqueness but serve as an instrumental case study by generating a number of findings that are transferable to other contexts.

An instrumental case study approach was adopted for the purpose of this study. In line with the objectives of the research, the case will serve to first, demonstrate how a social practices perspective could inform the researcher about the current transport situation and identify areas for substantial policy intervention. The use of an instrumental case study approach would also provide empirical evidence of how a social practice-based approach can be integrated with other methodologies, in this case a backcasting methodology and how such integration could be used to identify and evaluate alternative practice configurations. Lastly, the case study approach is helpful to demonstrate how policy pathways for bringing about a transition to low-carbon mobility can be developed.

### 4.4.2 Backcasting Methodology

The study adopts the Theory of Social Practice as the underlying framework to study how the transport sector can contribute to climate change mitigation and integrates this framework with a participatory backcasting methodology. Backcasting, which is one form of scenario analysis, is a useful technique that allows for transport policy to look at longer-term futures and design alternatives to break the current unsustainable trends (Ashina et al., 2012; Holmberg et al., 2000; Mattila et al., 2011; Van  Wee et al., 2004). The approach consists of setting desirable futures, and then examining the and paths by which those futures can be reached (Figure 4.2).

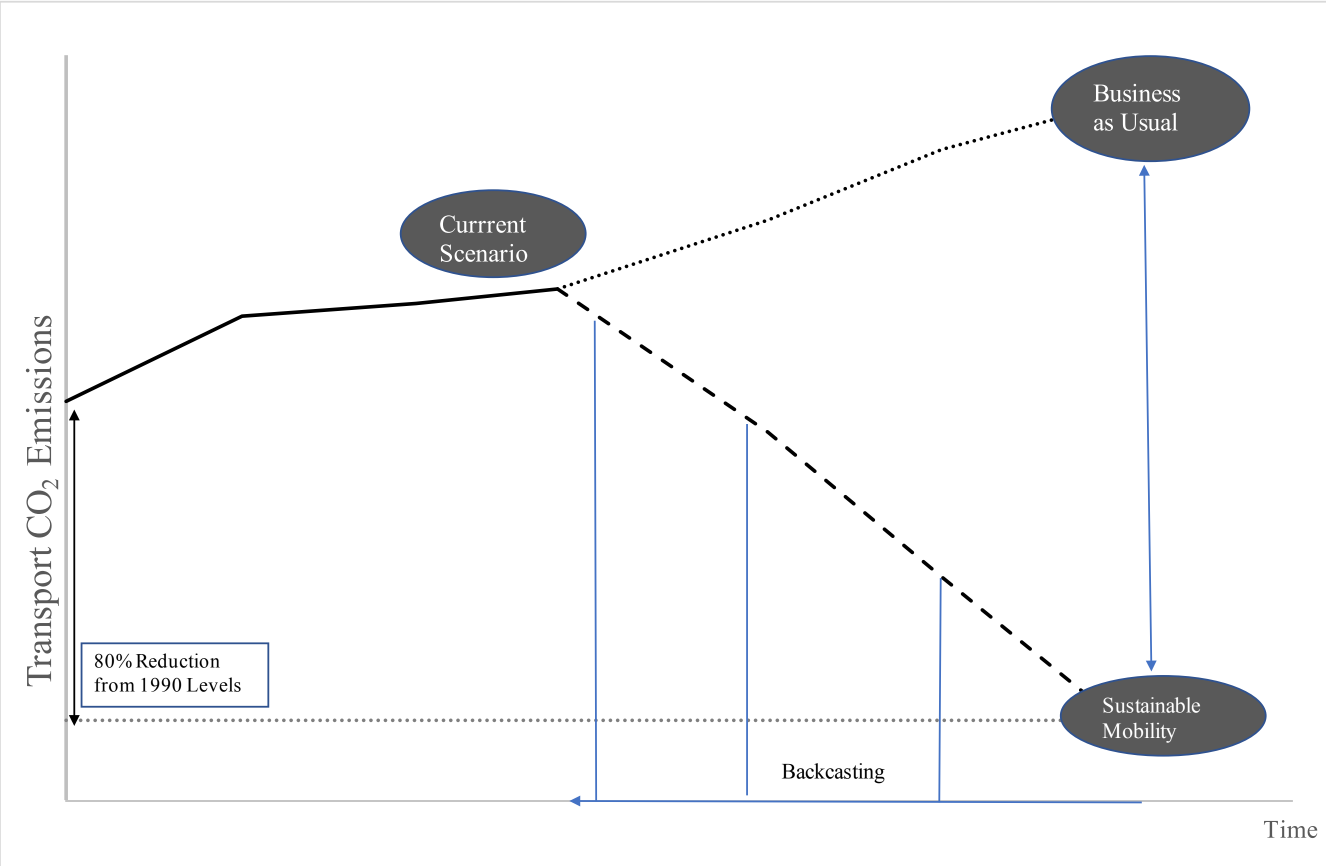



**Figure 4.2: The backcasting framework**
*Source: adapted from Camilleri et al. (2021)*

Backcasting studies are generally characterised by a number of different stages. However, the order and the number of steps differ between approaches (Banister et al., 2013; Höjer et al., 2000; Quist et al., 2001; Robinson, 1990). Despite this variability, it is possible to develop a methodological framework for backcasting (Quist, 2007). For the purpose of the present study the backcasting process as described by Banister and Hickman (2013); Hickman and Banister (2014) was adopted. The process has been shown to be adequate for identifying policy alternatives for low-carbon mobility and consists of five steps namely; i) context and baseline ii) visioning phase iii) scenario development iv) scenario assessment v) backcasting pathway (Figure 4.3). These steps were used as a framework for the methodology of this study.


**Figure 4.3: Backcasting Process**

### 4.4.3 Mixed-method approach

The framework in Figure 4.3 consists of a number of phases each of which answers different research questions and necessitated different methods of data collection and analysis. The research adopted a mixed-methodological approach to collect the data for the empirical study. Mixed methods involves combining or integrating qualitative and quantitative research and data in a research study (Bryman, 2016). These types of methods are based on the assumption that collecting diverse types of data provide a more complete understanding of the research problem than quantitative or qualitative data alone (Creswell et al., 2017).

Qualitative methods of data collection were the dominant approaches in this empirical research. While contributing to a smaller part of the methodology, quantitative techniques, were also an important component of the study. In this study, quantitative techniques were used to generate sets of data that fed into the backcasting process and upon which other phases of the study built. The next sections will guide the reader through each section of the research agenda. A description of the methods for data collection and analysis will be given. Section 4.5 will describe the methodologies to collect data to set the baseline for the study, Section 4.6 provides the methods to establish the transport future visions, Section 4.7 illustrates how the future visions were assessed for their suitability and Section 4.8, details the methods used to develop a set of policies for transport futures. The next sections will also serve to illustrate how the research design and methods are linked to the theoretical framework that underpins the study.

The data collection process involved the participation of human subjects who provided information through surveys, interviews, and workshops. The research was carried out following the ethical principles as approved by the University of Malta Ethics Committee. The methodologies were reviewed by the faculty research ethics and data collection was only initiated after approval was received (Unique Form ID: 210:26.11.18-Rosalie Camilleri).

## 4.5 Phase one: Context and Baseline

The first step in the backcasting process is establishing the context and the baseline for the study. This phase of the backcasting process aims to answer the first research question: *What are the current types of mobility practices in Malta? What are the current $CO_2$ emissions from transport?*

This section will focus on defining the methods of this first phase of the research, which as discussed below, involves establishing:

i) the desired goals or targets for the long-term future
ii) the timeline for attaining these targets together
iii) the baseline that reflects the business-as-usual projection
iv) the context of the study which reflects the current transport situation

### 4.5.1 Targets for the long-term future

First, the targets for the backcasting process were based on the research aim – that of reducing the $CO_2$ emissions from the transport sector and achieving the climate change reduction targets for Malta. In this context, the targets set for the backcasting process were the percentage $CO_2$ emission reduction for the transport sector. The end-term target for this backcasting study was an 80% reduction in the $CO_2$ over the 1990 levels. This goal reflects the recommendations of the IPCC and its 4$^{th}$ Assessment Report, which states that industrialised countries should lead by example and take more stringent emission reduction targets, and aim to reduce their emissions by 80% below the 1990 levels (IPCC, 2007). A similar target is also taken by the EU which, in its 2050 roadmap, aims to reduce emissions in line with the commitments taken by developed countries (European Commission, 2011a). Applying this target to the transport sector and assuming the contribution of road transport to be 25% of the total emissions, it follows that emissions from road transport must be kept below 119 kt$CO_2$ equivalent.

### 4.5.2 Timeline for Backcasting

Secondly, the backcasting approach is well-suited for long-term sustainability challenges. Similar studies which have looked at the emission reduction potential from transport utilising a backcasting approach set long term targets which span from 15 to 30 years in the future (Banister et al., 2013; Peeters et al., 2010; Schade et al., 2005). For this study, the year 2050 was set as the target year for exploring how reductions in GHG emissions in the transport sector can be achieved. The choice of 2050 as the target date enables the avoidance of the cumulative effects of transport and allows enough time for effective actions (European Commission Joint Research Centre, 2008)

### 4.5.3 Baseline

To identify the degree of change required to meet the set emission targets, a baseline or business as usual (BAU) emission scenario was first developed. The BAU scenario is a reference scenario that reflects the continuation of present trends in transport, moderated by likely trends in legislation and technology (Van  Wee et al., 2004). Differences between the BAU forecasts and the desired goals are important for identifying the key policies that are necessary to break the prevailing unsustainable trends (Hickman et al., 2007). Different methodologies have been adopted in backcasting studies to define the baseline or the BAU scenario (Hickman et al., 2010; Hickman et al., 2012; Mattila and Antikainen, 2011; Tuominen et al., 2014; Soria-Lara and Banister, 2018a). The review of policy documents and strategic plans for example, is one way in which the main drivers of transport and mobility demands can be identified and hence a BAU projected (Soria-Lara et al., 2017b). Other approaches include modelling techniques that estimate the GHG emissions for the BAU scenario. These include models based on transport forecasts (Robin Hickman et al., 2010; Hickman et al., 2012) and other modelling approaches which have taken into account socio-demographic, economic megatrends and trends in energy consumption (Ashina et al., 2012; Mattila et al., 2011). A national transport model with emission calculation systems which are capable of forecasting in the long-term future have also served for the purpose of developing the baseline and BAU scenarios (Tuominen et al., 2014).

This study uses a modelling exercise to quantify the current $CO_2$ emissions from transport and make projections of the emissions under the BAU scenario. A pre-defined model of emission calculation, ForFITS (https://unece.org/forfits-model-assessing-future-co2-emissions) was used to estimate the emissions from transport at baseline year and target year. The same model was used for the assessment of scenarios step in the backcasting process. The choice of this model for quantifying emissions and the characteristics of the modelling exercise will be discussed under section 4.7.1.

### 4.5.4 Setting the context: identifying elements of current mobility practices

***Semi-structured Interviews***

The first step of the backcasting process is also characterised by the definition of the current situation with the aim of identifying the key sustainability challenges (Doyle et al., 2013; Vergragt, 2005). The methods chosen for this phase of the study were based on the Theory of Social Practice, which underpins the study. A qualitative approach was designed with the aim of understanding the elements of the current mobility practices in Malta.

The three-element model (materials, competences and meanings) proposed by Shove et al. (2012) was used as the guiding principle to identify the elements of mobility practices. This model has been the most extensively described in the literature and is the most adopted amongst the practice theoretical based research, hence the choice for it in this study. The identification of the elements tied to a given practice required in-depth analysis that could explore the range, variety and extent of different beliefs, understandings and elicit explanations and empirical details in social narratives and discourse (Cass et al., 2016). As shown through several studies based on a practice theoretical perspective (Halkier et al., 2011; Martens, 2012; Phoenix et al., 2014; Spotswood et al., 2015), this normative and interpretivist approach necessitates qualitative methods of analysis. Qualitative research methods are valuable for understanding the underlying context behind the motivations in people's travel patterns and exploring hidden meanings, perceptions and attitudes (Lucas, 2013). In contrast with the quantitative methods, qualitative methods allow a grasp of the individual's own explanations of the emotions, attitudes and behaviour towards travel (Grosvenor, 2000).

The exploration of the elements of a given practice (e.g. mobility practice) necessitates a qualitative study of everyday lives and their context (Shove and Walker, 2010; Cass et al., 2015; Cass and Faulconbridge, 2015; 2016; Mattioli et al., 2016). The use of semi-structured interviews has been recommended for practice-based research on the basis that the discursive interaction between researchers and research participants present a valuable method of exploring the structure of linkages between the elements of a practice (Martens, 2012). Semi-structured interviews are a type of interview where the interviewer attempts to elicit information from another person by asking questions. In this process, the interviewer prepares a set of pre-determined questions, yet the interview is set to unfold in a conversational manner offering the participants the chance to explore issues they feel are important (Longhurst, 2003). In semi-structured interviews, some questions or themes need to be planned ahead of time, but lines of enquiry are pursued within the interview. The researcher prepares an interview schedule however, the sequence of questions is varied and altered depending on the response of the interviewee (Bryman, 2016). This openness of the semi-structured interview allows the researcher to enter into a dialogue with the respondent and follow-up on interesting and unexpected avenues that emerge (Blandford, 2013).

The semi-structured interviews in this study consisted of open-ended questions that were aimed to draw information on the elements of the current mobility practices in Malta. Narrative interviews were used to map the participants' everyday life and how daily activities determine the way they travel. From these narratives, an insight on the elements (materials, competencies and meanings) making up the different forms of mobility was drawn. The interviews followed an interview guide which consisted of five parts and which can be found in Appendix A. In the first part of the interview, the participants were introduced to the aims of the study. This was followed by a set of opening questions (Part 2) focused on gathering information on the participant (demographics), but also on the background of the respondent. The third section of the interview (Part 3) was aimed at understanding the daily activities of the participants and how mobility fits into the routinized everyday life. Participants were asked to describe the activities they engage in their day-to-day life and how they travel to these activities. For this part of the interview, questions were left as open-ended as possible so that the participants' answers where not influenced by the questions of the researcher and an in-depth account of what goes on in daily lives could be provided.

The next section (Part 4) then involved more in-depth questions on the mobility practices that the respondent would have mentioned in Part 3. Questions were asked around the respondent's experience of the types of mobility they make use of, their perceptions, beliefs, skills required to entail the mobility practice and meanings they attribute to how they travel (Gosselain et al., 2011; Spotswood et al., 2015). For example, in order to understand what materials make up the mobility practice, the interviewees were asked "*Where does this practice start?*" and *"What happens during the travel/journey?"* Similarly, questions such as "*What do you value/enjoy about the way you travel?*" were included in the interview with the aim to uncover the meanings which the interviewee relates to his/her choice of mobility. Additional questions were aimed to prompt the interviewees to provide information on the competencies involved in the mobility practices they perform. To achieve this aim, similar studies have relied on questions about life histories whereby respondents were asked about the changes in their mobility throughout their life in an attempt to prompt them to reveal information on the skills tied to a given mobility practice (Cass et al., 2015). A similar approach was used in this study including questions "*How did you travel before you started using this mobility practice?*" and "*Can you explain changes in your travel behaviour over the years?*".

In the last section of the interview (Part 5), participants were invited to reflect on their travel mode choice to perform their day-to-day activities. Interviewees were asked to think of other modes of travel that they could use to perform their daily activities. These questions were intended to investigate the influence of other social practices on the mobility choices of participants.

The interviews were conducted between March and July 2019 and were held in different locations depending on the participants' choice, which included their private homes, workplaces, coffee shops, or the University campus. Each of the interviews lasted between 30 to 60 minutes and was audio-recorded. This including informing the participants with the aim and scope of the research, giving an overview of how the data collected would be treated and obtaining their consent before recording the interviews.

A non-probability sampling strategy was adopted for collecting the interview data. Non-probability sampling refers to an umbrella term for sampling techniques where the probability for each case to be selected from the total population is not known and it does not answer objectives that require statistical inferences (Saunders, 2009). Under this broad definition, there are various types of techniques including purposive sampling, which is most common amongst qualitative studies (Bryman, 2016; Simons et al., 2014; Wilmot, 2005). In purposive sampling, the selection of cases follows judgement or arbitrary ideas of the researchers looking for a kind of representative sample or diversity (Wolf et al., 2016). Furthermore, purposive sampling allows for the in-depth study of information-rich cases and from which issues of central importance to the purpose of the inquiry can be learnt (Padgett, 2016; Patton, 2002).

Several purposive sampling designs are possible in qualitative research, one such technique is maximum variation sampling where the target is to select cases for the purpose of documenting unique or diverse variations in the sample (Palinkas et al., 2015). This technique, which was at the basis of the sampling strategy for this research, ensures that many different variations of the data are explored and that the full range and extent of a phenomena are represented (Gina Marie Awoko, 2004; Higginbottom, 2004). The sampling technique calls for the definition of a set of criteria or themes for choosing the participants (Sandelowski, 1995). The criteria for participant selection are summarised in Table 4.3.

**Table 4.3: Criteria for purposive sampling**

| Sampling Criteria | Range to be included within sample |
|---|---|
| Age | 18 – 65+ |
| Place of residence | Covering all districts of Malta |
| Preferred mode of travel | car<br>bus<br>bicycle<br>walking |
| Lifestyle | students,<br>retired individuals,<br>persons in employment,<br>persons with care responsibilities |

A key determinant in the sampling strategy was the sample size. There is a wide range of views on what is a good sample size for semi-structured interviews. The choice of the participant number in qualitative research must be carefully considered since a very small sample size introduces the risk of inadequate depth and breadth while interviewing too many participants may produce superficial volumes of data (Sandelowski, 1995). As Dworkin (2012) notes, there are numerous guidance and suggestions on the number of participants that should be recruited for the study. He also notes that amongst this literature the suggested number of participants for qualitative studies spans in the range of 5 and 50. Other guidelines on sampling in qualitative research recommend using between 20 to 30 interviewees (Crowe et al., 2011; Morse, 2000). Based on these recommendations, a sample size of 20 individuals was targeted for this study.

***Data Analysis***

The first step in data analysis consisted in the transcription of audio-recorded interview data collected during the field study. Transcription is a vital part of qualitative research and it describes the phase of setting down the verbal research material in writing (Kowal et al., 2014). It is the first step in qualitative data analysis and allows for later organising the collected data and categorising the data into concepts (Sutton et al., 2015). The open-ended nature of qualitative data such as interview transcripts, makes the identification of data patterns more challenging than in quantitative data. One strategy that is often employed to overcome such challenge is thematic analysis (TA). TA has found application across most if not all qualitative research designs (Castleberry et al., 2018). TA can be described as a method of identifying, analysing and reporting patterns within data (Braun et al., 2006). This method of analysis is popular in qualitative research because of the wide variety of research questions and topics that can be explored (Vaismoradi et al., 2013).

Braun and Clarke (2006) describe a number of steps in the process of TA (Table 4.4). Following the transcription of the gathered information – the familiarisation phase – the next step in the TA process is coding which is defined as the process by which raw data are gradually converted into usable data through the identification of themes, concepts or ideas that have some connection with each other (Austin et al., 2014). Codes can take the form of a descriptive label and serve as a tag used to retrieve and categorize similar data. A coding strategy can be established before the coding begins (Boyatzis, 1998).

The codes which are used to map concepts are then categorised with each other to create themes. Themes can be described as patterns in the codes which capture important aspects about the data in relation to the research question (Braun et al., 2006). During this phase, the researcher starts gathering all relevant data into each potential theme and continuously reviews each theme to determine its robustness in relation to the coded extracts and data set (Castleberry et al., 2018). The final step in the thematic analysis process is the interpretation of the data presented as codes and then themes.

**Table 4.4: Process of Thematic Analysis**

| Analysis Phase | Description |
|---|---|
| Familiarising with data | Transcribing data, reading and rereading the data, noting down initial ideas. |
| Generating initial codes | Coding interesting features of the data systematically across the entire data set, collating data relevant to each code. |
| Searching for themes | Collating codes into potential themes, gathering all data relevant to each potential theme. |
| Reviewing themes | Checking if the themes work in relation to the coded extracts and the entire data set. |
| Defining and naming themes | Ongoing analysis for refining the specifics of each theme and the overall story that the analysis tells, generating clear definitions and names for each theme. |
| Producing the report | The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a report of the analysis. |

*Source: Braun et al. (2006)*

In TA, specialist software is available to facilitate the organisation process. Such software are known as Computer Assisted Qualitative Data AnalysiS or CAQDAS (Froggatt, 2001). NVivo is one such software used to provide the technological support for qualitative research (Castleberry et al., 2018). This software was used in this research to aid in the coding and thematic analysis of the data collected from the semi-structured interviews.

The primary aim of the thematic analysis was to draw conclusions on the elements of the current mobility practices based on the interviewees' perspective. The three-element model of social practices as proposed by Shove et al., (2012) was used to guide the thematic analysis. An inductive-deductive approach to the thematic analysis was adopted. During the deductive approach, (or concept-driven approach) the researcher tests the implications of existing theories or explanatory models about the phenomenon under study against the collected data. On the other-hand, the inductive approach (or data-driven approach) is characterised by a search for patterns where the researcher looks for similarities and differences in the data and moves from the data to a theoretical understanding (Graneheim et al., 2017). For this study a mixed inductive-deductive method of qualitative data analysis was used.

In the first step of this thematic analysis, a deductive approach was adopted where the narratives from the field study were examined for the occurrence of reference to the elements (materials, competencies and meanings) of the mobility practices. For this exercise, the three element model of social practice (Shove et al., 2012) was used as the basis for creating themes and codes during the analysis. The second stage of the analysis consisted of a more inductive approach where the narratives were screened to draw information about the constitute elements of mobility practices. In this inductive approach, the narratives themselves were used to identify themes which would provide an insight into the elements of the different practices.

### 4.5.5 Setting the context: identifying influence of other social practices on mobility

In addition to the semi-structured interviews, an ethnographic investigation aimed at capturing how different everyday practices influence mobility practices was also carried out. In understanding how social practices interact and bundle with mobility practices, a travel survey was used to collect the data.

#### *Survey Design*

Travel/activity diaries have found many applications in transport research to collect data on the individual and household travel for the purpose of planning applications as well as for more in-depth studies on travel behaviour (Greaves et al., 2015). The travel diary takes the form of a questionnaire where the participant is asked to record his/her travel throughout a selected day or days. In the process, the participant is also asked questions on the purpose of the trip, length of the trip and starting location and destination of the journey. Other information that the participant is requested to enter includes the mode of travel and the number of persons travelling with the respondent (Stopher, 1992; Greaves et al., 2015). The travel diary was well suited for collecting information on how different social practices influence mobility practices. This is because, in addition to the number and type of trip, the participant is asked to provide information on the purpose of the trip or the activity for which the journey was necessary (Axhausen et al., 2002), which information was then used to extract information on which everyday social practices interact or bundle with mobility practices.

Kenyon (2006) suggests that a good design for a travel dairy should have the following key characteristics i) quick and intuitive to complete, ii) have a shallow learning curve, iii) prompt the participants for the required information at every stage. For this case study, a travel/activity diary survey was developed to collect data on social practices vis-à-vis mobility practices. The survey questionnaire consisted of three sections. The first section was aimed to collect the socio-demographic data (e.g. age, sex, place of residence, economic status and type of employment) of the participants. The second section then asked the participant to record the travel data for a typical weekday. The third and final section prompted the participants to list information on the travel activities for a typical weekend. The questionnaire can be found in Appendix B.

***Sampling and Response***

The aim of the questionnaire was to produce a snapshot of a range of mobility practices and how these are influenced by other practices. The purpose of the survey was to supplement the data collected from the interviews by providing a broader view of the range of mobility practices and the activities that determine how people travel. An online survey method was adopted for this part of this study. Online surveys are considered an appropriate format for surveys when research costs are a constraint and timeliness is important (Benfield et al., 2006). These types of surveys offer a number of advantages over other research methods. For example online surveys are known to facilitate the interaction between surveyors and respondents, and reduce cost, time and data entry errors (Evans et al., 2005). Other than saving time and money, on-line surveys are also known to give the researcher access to unique populations which are otherwise difficult to reach.

On the other hand, there is little control on the selection of the participants. Sample representativeness is one of the issues in online surveys. Most often, lack of representativeness in online surveys arises through self-selection since participants who respond may be especially motivated or interested in the research topic (Thompson et al., 2003). Despite this limitation, Gosling et al. (2004) report that results from this type of sampling technique compares favourably to other sampling methods in which the representativeness of the sample can be determined. Furthermore, these sampling issues are less of concern when non-probability sampling (such as in the case of the present research) is sought (Wright, 2005).

A random probability sampling approach, where everyone in the population has an equal chance to be selected to be a part of the sample (Bryman, 2016) was employed for collecting the data. A 95% level of confidence and a 5% margin of error were assumed and used as the basis to calculate the sample size required for significant results. An on-line tool (https://www.surveysystem.com/sscalc.htm) was used to calculate the sample size at the desired level of confidence and margin of error as summarised in Table 4.5.

**Table 4.5: Sample size calculation and survey responses**

| Year of Study | Maltese Population | Confidence Interval | Confidence Level | Sample Size Needed | Number of responses |
|---|---|---|---|---|---|
| 2018 | 493,559 [a] | 5 | 95% | 384 [b] | 400 |

[a] *Source: NSO (2019)*
[b] *calculated based on: https://www.surveysystem.com/sscalc.htm*

***Survey Dissemination***

The data collection was initiated on the 24th February 2019 and responses were received through the following three weeks. During this period, participants from the target population (persons living in Malta) were invited to take the online survey but submitting their response through an on-line link. Invitation to participation in the questionnaire was made through advertisement on social media channels and further dissemination through e-mail addresses of the students at the University of Malta. Throughout the data collection process, the responses were monitored, and the demographics of the initial set of respondents was analysed. The recruitment of additional participants was then based on the data collected, with adverts targeted at segments of the population which were under-represented in the initial set of responses. This methodology for data collection was adopted to minimise sampling bias and lack of representativeness to the general population. The survey was terminated once the total number of responses reached 400, which is higher than the required sample size.

Following the survey, the responses were imported into Microsoft Excel and were checked and cleaned. The data was entered in the statistical package SPSS to be further processed and analysed quantitatively.

***Statistical analysis of the travel survey data***

The aim of the travel survey carried out as part of this empirical research was to understand the current mobility practices and how these interlock with other social practices. This understanding required statistical analysis of the data collected that would provide a picture of which modes of mobility are most prevalent in Malta and which social practices are dependent on what type of mobility for their performance.

The data was first explored through descriptive statistics. This preliminary analysis was useful to understand the basic characteristics of the dataset including the characteristics of the sampled population and the distribution of the data. It also helps to relate the characteristics of the sample to the general population. Descriptive statistics included estimation of the distribution of the data across the geographical context, age structure and gender amongst other characteristics.

The travel-diary type data was first screened to remove any missing or erroneous data. Descriptive statistics were used to show the share of modal choice amongst survey participants. Descriptive statistics often characterise the analysis of travel-diary studies which aim to mine information about those activities which cause the demand for travel (Axhausen et al., 2002; Harvey, 2003). This step involved the identification of the types of activities that the participants included in their travel diaries. Descriptive statistics were used to measure the frequencies of different activities that individuals participate in and travel to and identify the preferred mode choice for different types of activities.

## 4.6 Visioning Phase

Following the establishment of the baseline and the context for the backcasting exercise, the next step consisted in the visioning phase. This phase involved the construction of a series of desirable and alternative future images. The visioning phases targeted the long-term future (25-30 years) (Banister et al., 2013). The aim of this phase of the process was the generation of ideas that provide different options and possibilities for reducing $CO_2$ emissions from the transport sector in Malta in the year 2050.

The visioning phase of the backcasting exercise took the form of a participatory approach. The Theory of Social Practice was again used to guide the process. The approach relied on the involvement of stakeholders for developing desirable images of the future and for moving beyond the present unsustainable trends (Quist et al., 2006; Robinson et al., 2011). This normative approach to exploring alternative futures is known to offer several advantages over other techniques particularly by increasing the social learning among the stakeholders not only on the cognitive level, but also with respect to values, attitudes and underlying convictions. This process of social learning is very important when dealing with complex problems (Brown et al., 2003; Kerkhof et al., 2005; Robinson, 2003; van de Kerkhof, 2002).

A wide range of methods and tools are available for use in participatory backcasting (Quist et al., 2006). Such tools enable the involvement of stakeholders, the generation of the interactivity between stakeholders and subsequently scenario development (Quist et al., 2011). Four main participatory tools have been widely applied in the visioning phase of the backcasting processes:

a) stakeholder interactive workshops (Ahlroth et al., 2007; Carlsson-Kanyama et al., 2008; Eames et al., 2011; Green et al., 2002; Kok et al., 2011; Mander et al., 2008b; Quist et al., 2011; van de Kerkhof, 2002; Vergragt et al., 2007);

b) Delphi surveys (Eames et al., 2011; Gomi et al., 2011; Julio Soria-Lara et al., 2018; Soria-Lara et al., 2017b);

c) focus groups (Hickman et al., 2007; Svenfelt et al., 2011; van de Kerkhof, 2002);

d) semi-structured interviews (Soria-Lara et al., 2017b).

By far, the most commonly adopted approach in participatory backcasting approaches is the interactive workshop. The different methods of stakeholder involvement in backcasting exercises have their own advantages and disadvantages. Interviews, for example, allow for a potentially large sample size thus achieving a larger reproducibility and replicability (Street, 1997). In-depth interviews are a means of getting a clear picture of the participant's perspective on the research topic. In addition, such technique enables the researcher to question conflicting content directly (Harrell et al., 2009). Interviews are also more suitable for closely examining the views of individual participants independently from the views of other participants (Zimmermann et al., 2012b) and avoid situations where the opinion of some individuals is suppressed by the more dominant participants (Jan A. G. M. Van Dijk, 1990). Similarly to interviews, focus groups also suited for gathering in-depth information on a given topic and offer the opportunity for the researcher to question unclear content (Zimmermann et al., 2012b). Focus groups offer the advantage of generating many ideas in a time-efficient way (Svenfelt et al., 2011).

The Delphi survey on the other hand describes a technique where, through several rounds of questionnaires, consensus (or disensus) is reached amongst a group of participants. During the first round of questions, the participants exchange initial views which they revise during the subsequent rounds (Hsu et al., 2007). This method of participatory visioning represents a more closed process in contrast to other techniques such as the semi-structured interview or focus group. Amongst the advantages of the Delphi survey over other methods, one may mention the ease of reaching consensus, better accuracy and more willingness by participants to accept new ideas (Zimmermann et al., 2012b). On the other hand, it was found that the use of this technique may constrain the view of the participants when used in the visioning phase (Soria-Lara et al., 2017b).

Face-to-face stakeholder workshops have been identified as a powerful tool for achieving stakeholder involvement (Street, 1997) and constitute the most popular technique in participatory backcasting (Ahlroth et al., 2007; Carlsson-Kanyama et al., 2008; Eames et al., 2011; Green et al., 2002; Kok et al., 2011; Mander et al., 2008b; Quist et al., 2011; van de Kerkhof, 2002; Vergragt et al., 2007). As a general format, the approach consists in a group meeting which starts with the presentation of the problem statement and is followed by unstructured group discussions for generating ideas, and later, through a voting procedure for identifying priorities of consensus decision (Quist et al., 2001; Van De Ven et al., 1974).

One of the main advantages of workshops is that the technique enhances creativity as a means of vision development (Vergragt et al., 1998). In contrast to the more closed method of stakeholder involvement such as the Delphi survey and semi-structured interviews, workshops allow for greater interaction between relevant actors and exchange of various viewpoints (Quist et al., 2001). This interactive nature of the workshops provide opportunities for participants to enter into negotiation with one another facilitating social learning which is an important aspect of the participatory backcasting process (Patel et al., 2007). Workshops are also known to be a well-suited method for bringing different stakeholders' ideas together (Quist et al., 2001). This advantage stems from the fact that, as emphasized in the work by Quist (2007b), achieving a sustainable future requires the enrolment and co-operation between stakeholders from different societal groups. The integration between different stakeholders who serve to create and maintain elements of a given socio-technical system (in this case the transport system) serves to overcome a common system inertia that inhibit transitions (Guy et al., 2000).

For the visioning phase of the backcasting process, this study adopts a stakeholder workshop approach as the participatory tool for stakeholder engagement. This step of the backcasting process is aimed at meeting the second objective of the research agenda and aims to answer the second research question – *how can the current mobility practices be reconfigured to more sustainable forms?*

#### 4.6.1 Recruitment of stakeholders

The first step of the visioning phase consisted in the identification and recruitment of stakeholders for the visioning workshop. Stakeholder participation was a crucial element in the visioning workshop approach (Quist et al., 2006). Scholars have often defined stakeholders as all those having an interest at stake, or those that can affect, or be affected by, the achievement of organisational objectives (Freeman et al., 1983). This definition of stakeholder is rather broad and is open to many interpretations. Other scholars have given a more narrow definition of stakeholders such as that by Foley (2005), who views stakeholders as distinct from other affected or interested parties in having both i) the means of bringing attention to their needs and ii) the ability to take action if those needs are not met. The group of stakeholders can vary over time and is dependent on factors that determine the prevailing power balance among culture, type of market and government system (Garvare et al., 2010).

Backcasting is a normative type of scenario analysis where the goal is to design futures which are desirable rather than based on past trends (predicative) or explore situations that possibile to happen (explorative) (see Chapter 2, Section 2.6.1 for a description of different scenario types). The choice of the stakeholders for this case study reflected the normative nature of the visioning exercise, where the aim was to develop images of the future for a specific target ($CO_2$ emission reduction from transport) (Wangel, 2011a). To help guide the choice of the stakeholders, the methodology of stakeholder identification as outlined in similar backcasting studies was followed (Garvare et al., 2010; Quist et al., 2002; Soria-Lara et al., 2017b).

Five categories of stakeholders were identified:

- The public sector including public interest groups and consumers;
- Companies in the industry, their trade organisations and other representatives;
- Governments including government councils and government related

organisations;

- Research bodies including research institutes and universities;
- Others, including media, opinion leaders and educational bodies

These categories served to identify a list of stakeholders as potential participants to the visioning workshop as summarised in Table 4.6.

**Table 4.6: List of stakeholder identified as potential participants to the visioning workshop**

| Sector | Stakeholder |
|---|---|
| Public | Members of the public including different ages and social backgrounds |
| Government | Transport Regulator – Transport Malta |
| | Environmental Awareness – Environment and Resources Authority |
| | Climate Change – Malta Resources Authority |
| | Urban Planning – Planning Authority |
| | Energy - Water and Energy Agency |
| Research | University of Malta |
| Private | Bus Service Provider |
| | Car Importers |
| | Car Sharing service provider |
| | Bike Sharing service provider |
| Others | NGOs – Environmental Awareness |
| | Local Councils |
| | Ministry for Education and Employment |

### 4.6.2 The participatory visioning workshop

Once the relevant stakeholders were identified, they were invited to participate in the workshop. An invitation letter, which explained the aim of the study and the purpose for participation was sent to each one of the stakeholders. The response to the invitation was very positive with 80% of the stakeholders identified as possible participants agreeing to take part in the visioning exercise. The visioning workshop took place on the 12$^{th}$ February 2020 at the University of Malta Campus and involved a total of twenty-one (21) participants. The visioning workshop lasted for around three hours and the structure of the visioning exercise followed the format described in Quist et al. (2001) which was developed for previous work on backcasting for sustainable households. This format included three steps namely:

1. an introduction,
2. creativity session and
3. clustering and elaboration session

*The introduction*

The development of participatory backcasting has necessitated the development of novel tools and techniques that facilitate the role of individuals and decision makers in articulating desired futures and designing courses of action to reach their goals. Visualisation tools and scenario-building applications allow participants to be actively engaged in the creation of scenarios and their outcomes. Particularly, interactive tools and interfaces facilitate the understanding of the complex problems and the policy processes by the participants (Robinson et al., 2006; Sheppard et al., 2007).

The introduction step of the workshop took the form of a presentation where the participants were introduced to the research problem and provided with an overview of the baseline GHG emissions and business as usual (BAU) scenario together with the climate change mitigation targets for Malta. This was aimed to help the participants understand the degree of emission reduction from the transport sector required to achieve the mitigation targets. Since the visioning phase was designed following the Theory of Social Practice, it was also important that the stakeholders understood the theoretical concepts of practice theory. Thus, a part of the introduction was focused on providing a description of the basic principles of practice theory in particular, the elements constituting to a practice, how practices are sustained over time and how different social practices are bundled together.

The introduction to the workshop included a presentation on the range of mobility practices in Malta, the constituent elements making up these practices and the other social practices that complex with mobility. The data generated from the first phase of the process was used for this second phase to inform the participating stakeholders on the different mobility experiences as analysed through a practice theory point of view.

*The creativity session*

Following the introductory session, participants were asked to vision how changes in practices may deliver more sustainable mobility for the year 2050. This year was selected both because such timeframe gives freedom from the constraints of the current technologies, norms and interests (Doyle et al., 2013).

The interactive part of the workshop was facilitated by an online tool – Mentimeter (www.mentimeter.com) which is a real-time online application that allows participants to answer questions and provide personal views and discussions through a device connected to the internet (such as mobile phone, laptop, or tablet). The application allows participants to view the responses submitted in real-time hence promoting interaction between participants and enhancing group discussion through a social-learning process (Figure 4.4).

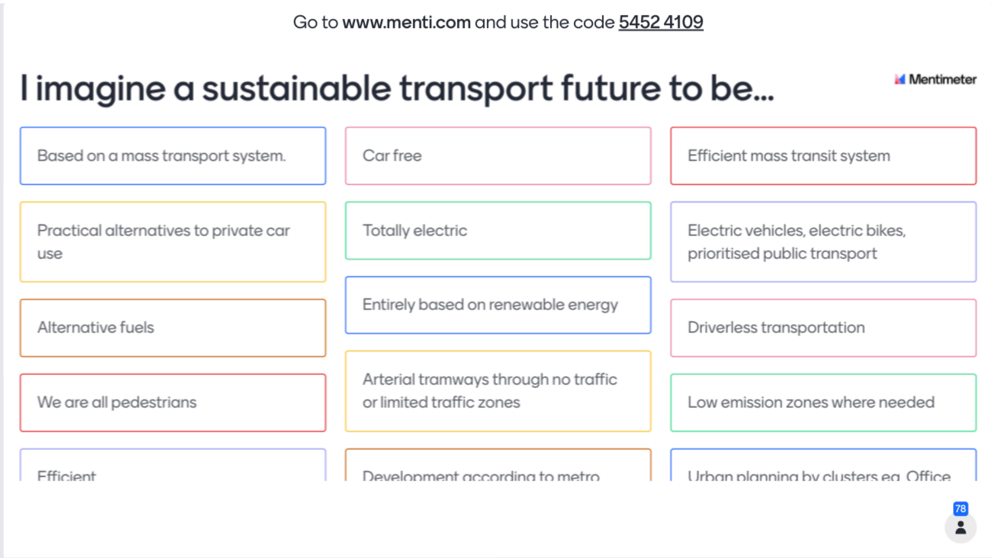



**Figure 4.4: Use of Mentimeter tool during the visioning workshop**

The participants were asked to imagine it was 2050 in Malta and the researcher guided the participants to describe visions for sustainable transport in this future. To help the participants understand the requirements of long-term visioning, examples from other future visioning projects, such as the visioning exercise in the UK (Office of Science and Technology Foresight Programme, 2006), as shown in Figure 4.5, were used during the workshop.

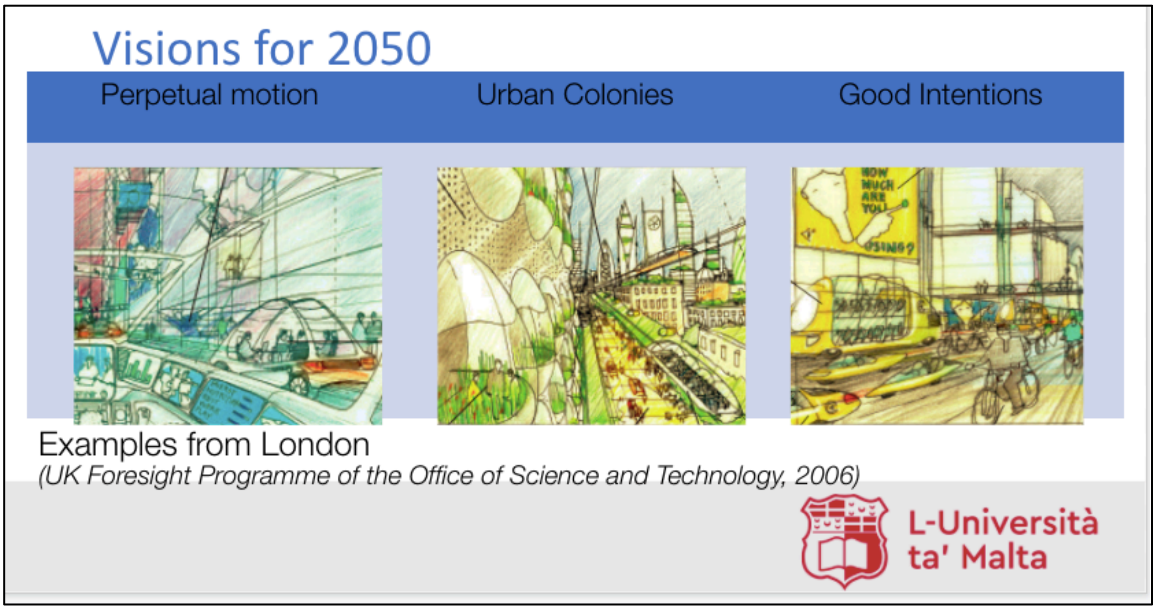



**Figure 4.5: Part of presentation given during the visioning workshop showing example from other projects**

After the first part of the interactive workshop was completed, the concepts generated were screened by the researcher, and similar concepts were grouped together. Two main themes under which the concepts could be classified became evident. On the one hand, there were those visions where the stakeholders imagined a sustainable future based on technological innovations. In contrast, the other group of concepts showed visions of sustainable transport where active travel was at the centre of mobility and urban planning.

The workshop participants were split into two groups. One group was asked to focus on the visions relating to technology, the other group on visions focused more on active travel. Each of the two groups was then asked to use the data on the elements of mobility practices in Malta presented in the introduction to answer three open questions. These questions are based on the report by Spurling et al. (2013) who suggest ways in which policy interventions can be configured from a practice theory perspective. The questions were structured as follows:

*Imagine it is the year 2050.*

1. *How would the elements of the mobility practices have been reconfigured to produce low-carbon forms of mobility practices?*

2. *Which innovative or alternative practices could have substituted the less sustainable practices?*

3. *How could the interaction between the different practices have been altered to promote less-carbon intensive mobility practices?*

The researcher guided the creative session and encouraged open, interactive discussion between the participants. In the process, the researcher aimed to mediate the discussion bringing everyone in, preventing dominance and steering the group away from irrelevant areas (Ritchie et al., 2003). The participants were invited to elaborate their ideas where these diverged from those of the other participants (Wangel et al., 2011). Throughout the process, the participants were prompted to put down the ideas generated during the interactive process on post-it notes provided by the researcher. These ideas were used in the clustering and elaboration session as follows.

***The clustering and elaboration session***

The participants were asked to take part in a clustering, discussion and rating exercise. A metaplan technique was utilised to guide the discussion (Schnelle et al., 1979). In this exercise, the stakeholders were asked to group the concepts generated in the previous step under three general clusters. One which included the reconfiguration of the elements of mobility practices, another describing innovative mobility practices and a third set of concepts describing how the interaction with other social practices can be altered. Following the definition of different clusters, participants were asked to vote for the concepts which in their opinion are the most suited for delivering sustainable mobility (Carlsson-Kanyama et al., 2008). In this exercise, the stakeholders were directed to rank the concepts as high priority, medium priority and low priority.

***Conclusion***

A face-to-face workshop was employed in the first phase of the backcasting. This participatory method was critical to bring together different stakeholders and their ideas about what a sustainable transport future would look like. The participants were first introduced to research problem and the business as usual (BAU) scenario. They were then asked to imagine a sustainable transport future and were guided to think how the current mobility practices elements can be reconfigured to reach sustainable futures. The concepts developed during the workshop were subject to a ranking and voting exercise. The next section will discuss how the results from the workshop were analysed and further developed into concrete transport future scenarios.

### 4.6.3 Data Analysis and Scenario development

The resulting data from the visioning stakeholder workshop was elaborated into alternative transport future scenarios for Malta in 2050. This step of the backcasting process, where the initial concepts and ideas established during the visioning workshop were transformed into narratives of different alternative transport futures, was carried out by the researcher as a desktop exercise. Various methods of scenario development are possible (Dean, 2019; Martelli, 2014). One of the most popular scenario planning approaches is the scenario-matrix technique (Krys, 2013; Van der Heijden, 2005; van't Klooster et al., 2006).

The scenario matrix starts with four quadrants that explore various scenarios in relation to two polarized sets of variables (van der Duin, 2016) which represent the two most important critical uncertainties. The potential future developments of these uncertainties, are plotted respectively onto the x and y axes of a the 2x2 matrix. This technique produces four different possible scenarios as shown in Figure 4.6.

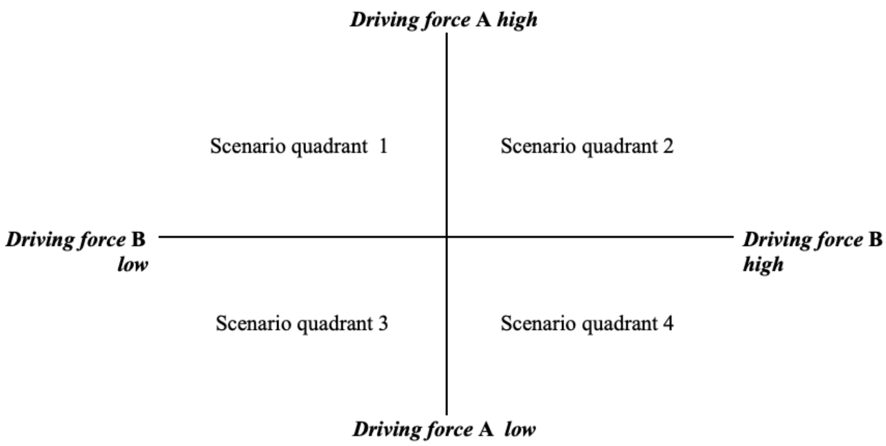



**Figure 4.6: 2x2 scenario matrix for developing scenarios**
*Source: van't Klooster et al. (2006)*

The scenario axis in this study were constructed based on the stakeholders input during the visioning workshop as described in section 5.4.5. The visioning exercise produced concepts that could be classified under two themes. These themes were used to set the axes, where one of the axes represents high and low technological innovations while the other represented a high degree of active mobility at one end and a low degree of active mobility at the other (Figure 4.7).

The next step after the axis of the scenario matrix were established consisted in the development of scenario narratives. Again, the concepts generated during the visioning workshop were used for scenario development. Following the visioning workshop, the researcher fitted the concepts generated from the clustering and elaboration session of the workshop into the different scenario matrix categories. Once all the concepts were assigned to the four scenario quadrants, they were further elaborated into scenario narratives. The results of this exercise generated four different scenarios, one business-as-usual scenario and three alternative scenarios.

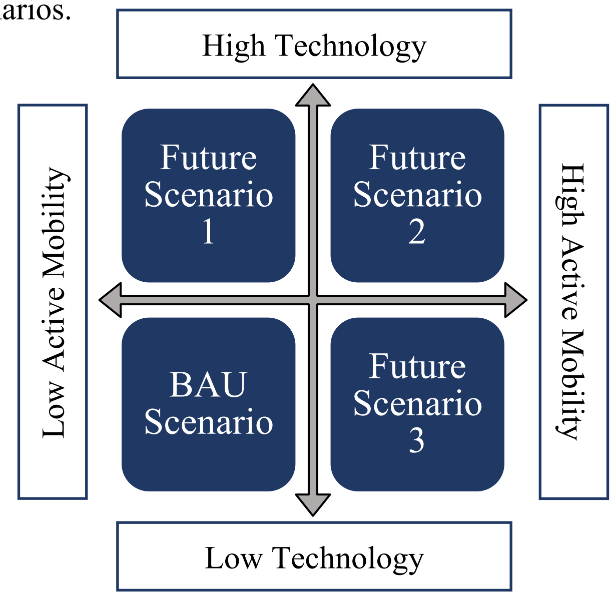



**Figure 4.7: Scenario matrix and axis for scenario development**

Once the scenarios were developed, they were disseminated (through electronic mail) with the stakeholders for further feedback. A on-line survey method using Google forms was used to collect input from the stakeholders and which can be found in Appendix C. The data collected was downloaded and analysed qualitatively by the researcher. Further concepts developed during this feedback stage, were used in an iterative process to further elaborate the scenarios. This further elaboration of the scenario was an important step that allowed the stakeholders to have a sense of ownership of the proposed scenarios and enhance further the participatory and collaborative manner in which this approach was developed (Doyle et al., 2013).

## 4.7 Assessment of Scenario Suitability

This section of the methodology aims to answer the third research question namely; *What are the likely impacts of such reconfigurations on the $CO_2$ emission from transport?* The focus of this section is the evaluation of the future scenarios generated during the visioning phase of the backcasting technique. This phase of the backcasting process aims to assess the alternative scenarios in terms of their suitability to meet the set emission reduction targets.

Literature on backcasting studies illustrate how scenarios developed from the visioning phase of the process are subject to some form of sustainability assessment (Åkerman et al., 2006; Hickman et al., 2012; Julio A. Soria-Lara et al., 2018). This assessment provides an indication of the suitability of the scenario for reaching the sustainability goals and is important for subsequent phases of the backcasting process. The sustainability evaluation of scenarios is especially important in the case of target-oriented backcasting (Börjeson et al., 2006) where the aim of the scenarios is to reach a quantifiable goal such as that of emission reduction.

Amongst the backcasting studies several different techniques have been employed in the evaluation of scenarios. Within the range of techniques for scenario evaluation, one can find both quantitative and qualitative methods. Sustainability appraisals for example are one set of assessment tools that allow for the simultaneous assessment of environmental, social and economic impacts of a scenario or decision. These types of assessments typically rely on semi-quantitative or qualitative data for analysis (Giurco et al., 2011; Nijkamp et al., 2000; White et al., 2006). Multi-criteria analysis is one example of a sustainability appraisal that relies on a qualitative methodology for the assessment of different scenarios. This type of appraisal has found application in backcasting exercises in transport policy (Hickman et al., 2012; Julio Soria-Lara et al., 2018). Other backcasting projects have relied on the quantification of $CO_2$ emissions resultant from different scenarios (Tuominen et al., 2014).

The choice of the approach adopted to evaluate the scenarios strongly depends on the target of the scenario development or the backcasting approach in general. In the case of the current study, the target of the backcasting process is to identify policy pathways that can achieve the required reductions in $CO_2$ emissions to meet the climate change mitigation targets. Hence the choice of the methodology of scenario assessment needs to reflect the requirement of assessing the scenarios against a quantitative target. This necessitates a quantitative method of evaluation.

### 4.7.1 Choice of modelling tool

Transport modelling represents one quantitative tool which has been applied in research that aims to explore different scenarios of transport futures. This tool is valuable in providing insights into the contribution of emissions under different scenarios and the challenges that are faced in reaching the emission reduction targets. There are various types of transport models, with wide-ranging scales of modelling and model outputs. The choice of the model from the wide range of transport modelling approaches depends on the scale, the scope of the analysis and the availability and cost of data required to run the model (Linton et al., 2015).

As described in the literature review, in Chapter 2 (Section 2.6.4), the system dynamic modelling is well-suited to strategic policy analysis and as a support tool for decision making. The main advantage of system dynamics is that this type of approach accounts for the complexity of the transport system which involves different elements interacting together creating feedbacks with different response time (Abbas and Bell, 1994).

Some researchers employing system dynamics modelling in their research have relied on their own specific model which is adapted to the needs and context of their study (Liu et al., 2015; Stepp et al., 2009; Wang et al., 2015). There are other examples where researchers have opted to use pre-existing system dynamics model for the assessment of the environmental impact of transport measures. ASTRA (Assessment of Transport Strategies) is one example of an pre-existing model which is used to analyse the long-term effect (up to 2030) of transport policies (Fiorello et al., 2010). Another similar model is the MARS (Metropolitan Activity Relocation Simulator) model which is useful for scenario testing, policy optimization and decision maker training (Guzman et al., 2015; Pfaffenbichler et al., 2010). In addition to these two models, ForFITS (For Future Inland Transport Systems) is another tool which has found application in the evaluation of the impacts of transport policies on $CO_2$ emissions (T. Andrejszki et al., 2014). This tool was developed by the United Nations Economic Commission for Europe (UNECE) and it is aimed to help strategic decisions in local policies. Table 4.7 summarises the properties of these models.

The use of pre-existing models offers a number of advantages over the use of models which are specifically designed for a study. First, the models would have been based on existing knowledge that a team of developers who have acquired, thus this knowledge would already be included within the model (E. Menezes, A.G. Maia, et al., 2017). In addition, pre-existing the models would have been tested and validated thus providing a more robust platform than those which are developed for one study. Most of the pre-existing models have been developed to cover different contexts and allow transferability between cases, which allows for comparison between different studies (Shepherd, 2014).

**Table 4.7: System dynamic models for $CO_2$ emission calculations**

| Model | ASTRA | MARS | ForFITS |
|---|---|---|---|
| Developed by | European Union | EU-research project | UNECE transport |
| Geographical scale | European Wide | Regional Scale | National / Local scale |
| Temporal Scale | 30 years | 30 years | 30 years |
| Main Modules | Population, macro-economic, regional economic, foreign trade, transport, environment, vehicle fleet, welfare measurement | Transport, housing development, household location choice, workplace development, workplace location, fuel consumption, fuel emissions | Passenger transport demand generation module, Freight transport demand generation module |
| Data Inputs | Trip rates, transport costs, transport times, emission factors, vehicle occupancy. | Fleet composition, Land use and employment location data | Passenger transport system characteristics, vehicle fleet, passenger-kilometres, powertrain distribution. |

*Source: Author's summary based on Andrejszki et al., (2014); Pfaffenbichler et al. (2010b); Schade and Krail, (2006); Menezes et al. (2017)*

ForFITS model has been tested in a pilot project in seven countries including Chile, Ethiopia, France, Hungary, Montenegro, Thailand and Tunisia (UNECE Transport Division, 2014). The purpose of this pilot project was the validation of the model and the project served to prove that the model was efficient in estimating the emissions from transport under different scenarios. The project also demonstrated that the model is applicable to different geographical regions which represent different scenarios in terms of vehicle fleet and macro-economic conditions.

In addition to the pilot project, the model features in a number of studies and peer reviewed articles (T. Andrejszki et al., 2014; Marc Georges Haddad et al., 2018; E. Menezes, AG. Maia, et al., 2017; J Zawieska et al., 2018) that aim to evaluate the proposed strategies and policies to reduce emissions from transport, to assess the potential impact of such strategies and their implications on decision making. In a study based on the urban transport sector in a Brazilian megacity, the model was used to evaluate policy scenarios and their impact on GHG emissions

(E. Menezes, A.G. Maia, et al., 2017). The study first selected a set of options for low-carbon transport based on an extensive literature review, and these were further elaborated after discussions with stakeholders. This exercise resulted in five different strategies which included; a) the promotion of teleworking, b) increased shared mobility, c) improvements in public transport; d) improved vehicle efficiency, e) increase in the use of biofuels. These policy scenarios where evaluated using the ForFITS model and compared to the business as usual (BAU) reference scenario. The results of the study found that the model was a useful tool to aid policy makers understand the likely effects of GHG mitigation policies and the possible interactions between different policies.

ForFITS model was used in a similar study, this time based on the land passenger transport in Hungary (T. Andrejszki et al., 2014). The research focused on the long-term forecast and related emissions of the transport sector under four different future scenarios that included a mix of policies that are aimed; to shift behaviour, introduce new vehicle technologies, increase the use of biofuels, and introduce taxes on fuel. These scenarios were again compared to the BAU scenario to assess their effectiveness. This study showed how ForFITS is used for the assessment of transport policies including those related to behavioural changes. In another study, ForFITS was employed to analyse the future trends for GHG emissions and energy consumption of Lebanon's road transport sector (Marc Georges Haddad et al., 2018). Four scenarios which included a BAU scenario were modelled in this study, to show the potential impact that different policies have on emissions. The policy options included those that aimed to increase the share of fuel-efficient vehicles, hybrid vehicles and mass transport.

Similarly, the model was used to forecast $CO_2$ emissions for the transport system in Warsaw (Poland) under three scenarios up to the year 2050 (J. Zawieska et al., 2018). One of the scenarios included the BAU which served as a reference to the assessment of the other scenario options. The other two scenarios assumed different degrees of improved energy efficiency and changes in vehicle technology. In conclusion it was found that ForFITS is a suitable model for the assessment of backcasting scenarios with quantifiable goals such as in this study.

#### 4.7.2 Modelling the $CO_2$ of future scenarios

This section describes the modelling exercise used in the assessment of the alternative transport future scenarios. The pre-define model ForFITS was used to make calculations on levels of $CO_2$ emissions under different scenarios. ForFITS is an open sourced software which is freely available form https://unece.org/forfits-model-assessing-future-co2-emissions. Model calculations are based on information about the transport system characteristics and the macro-economic parameters. To be able to model emissions under different scenarios using ForFITS model, instructions on model operations which are also freely available with the model were utilised by the researcher. To supplement this material on the operation of the model, studies found in literature which were alos based on this model were utilised (T. Andrejszki et al., 2014; Marc Georges Haddad et al., 2018; E. Menezes, AG. Maia, et al., 2017; J Zawieska et al., 2018). The modelling exercise required a learning curve with a number of trial model runs before the actual scenario emission model runs.

The model produced a number of output parameters which include:

i) $CO_2$ emissions under three classes
   a. Tank-to-wheel (TTW) emissions which are a result of fuel use and energy consumption
   b. Well-to-Tank (WTT) emissions which represent the emissions during the production phase
   c. Well-to-wheel (WTW) emissions which are generated during the complete fuel life cycle and are a result of the TTW and WTT emissions

ii) The activity intensity of the transport system for the different transport modes, calculated in vehicle kilometers (vkm) and passenger kilometers (pkm).

iii) Total energy used by the transport system divided per mode.

Estimation of $CO_2$ emissions in ForFITS is based on the ASIF scheme where emissions are expressed as the product of vehicle activity (in vkm) (A), sectoral structure as shares of vkm by mode and powertrain (S), energy intensity as the average fuel consumption per vehicle type (I) and carbon intensity of the fuel type equivalent to the emission factors (F)

GHG emissions = A S I F

The modelling exercise required input of a set of macro-economic parameters and transport related variables upon which the scenarios could be modelled.

A set of input parameters are shared by all four scenarios. These parameters are summarised in Table 4.8, together with the sources from which such information was derived and consist of:

i) the period of analysis spanning from 2018 to 2050
ii) macroeconomic data:
  a) demographic parameters: population and population growth by 2050
  b) economic parameters: gross domestic product (GDP) and growth assumptions by 2050
iii) characteristics of the transport system at base-year: vehicle stock, type of fuel used in each category, average distance travelled by type of vehicle and fuel consumption characteristics.
iv) emission factors: well-to-wheel (WTW) and tank-to-wheel (TTW) emission factors for different fuel blends.

**Table 4.8: ForFITS main input parameters and sources**

| Variable | Input Parameter | Sources and estimates |
|---|---|---|
| Socioeconomic variables | Population | National Statistics Office Regional Statistics (NSO, 2019) |
| | GDP | World Economic Outlook Database (International Monetary Fund, 2019) |
| | Population Growth | Projections of population growth by Eurostat (Eurostat, 2020b) |
| | GDP Projections | Projections by the EU Commission (European Commission Directorate Genral for Economic and Financial Affairs, 2018) |
| | | |
| Sectorial variables | Stock of vehicles by mode and type | Data compiled by the National Statistics Office (NSO, 2020) |
| | New registered vehicles (base year, base year minus five, base year minus 10) | Data compiled by the National Statistics Office (NSO, 2009, 2014, 2020) |
| | Average annual kilometers traveled per vehicle | National Data on Transport System (NSO, 2020) |
| | Average number of passengers per mode | National Transport Strategy and Master Plan (Transport Malta, 2016a) |
| | | |
| Time-dependent variables | Emission Factors (Tank-to-wheel and Well-to-Tank) | Emission Factors developed by UNECE and inputted in ForFITS (UNECE Transport Division, 2014) EU Commission Joint Research Centre Technical Report on Tank-to-Wheel emissions in the EU (Hass H et al., 2014) |
| | Fuel prices and taxes | Transport fuel prices and Taxes in Europe (European Environment Agency, 2019) |
| | Fuel consumption characteristics | Average specific consumption of cars in the EU (Enerdata Research Service, 2018 ) |

The first step consisted in the modelling of $CO_2$ emissions in the Business as Usual (BAU) scenario. This scenario represents a continuation of current trends in transport policies and estimation of emissions under this scenario required a number of assumptions as summarised in Table 4.9.

**Table 4.9: Assumptions made to estimate $CO_2$ emissions under BAU scenario**

| Parameter | Assumption |
|---|---|
| *Energy efficiency* | Increases after 2025 and again after 2030 based on the EU regulations on emissions for cars and vans (European Commission, 2019). |
| *WWT and TTW emission factors* | Assumed to decrease by 10% by 2050 for all fuel types assuming the implementation of EU Directives on the share off bio-fuels and renewable energy (European Commission, 2009a, 2009c). |
| *Powertrain shares* | No changes in shares of different powertrains are assumed to the year 2050. |
| *Fuel prices and taxes* | Assumed to remain unchanged by 2050. |
| *Passenger transport system index and Environmental culture index* | These parameters represent the development of the share of public transport system and environmental awareness of the passengers. For the BAU these parameters are assumed to remain constant up to the target year. |

The modelling exercise then consisted in the variation of different parameters of the transport model such as to simulate the changes in the transport system under the different transport future scenarios. For all scenarios, the emissions were modelled from the base-year to the target year 2050. The assumptions made during the modelling of the alternative scenarios will be discussed together with the outputs, in the results Chapter 7 (Sections 7.4 -7.6).

## 4.8 Transition Phase

This section of the methodology describes the transition phase of the backcasting process. This phase of backcasting involved the development of different policy pathways that span from the baseline year to the target year. This section of the methodology was aimed to answer the fourth research question; *what policy pathways can be developed to achieve practice reconfigurations?*

The aim of the transition phase in the backcasting process is to design interventions that lead towards the scenarios developed in the earlier stages of the process. As a continuation of the previous steps in the backcasting process a participatory approach was adopted for the transition phase. Visions of the future were used as the starting point of the transition phase and this was followed by stepping backwards to the present.

### 4.8.1 Stakeholder led policy pathways

***Survey with stakeholders***

Amongst participatory backcasting studies, it is common that the stakeholders who have defined the future end points, then explore the gap between the desired future and the current conditions and develop objectives and policy pathways to reach that future vision (Iacovidou et al., 2014; Mattila et al., 2011). The transition step is often characterized by a discussion between stakeholders which is stimulated and oriented towards the main steps that need to be taken, the obstacles that need to be overcome and the opportunities that should be seized for the realization of the selected visions (Kerkhof et al., 2005). A range of methods are available for engaging participants in the transition phase of backcasting. These include face-to-face workshops (Banister et al., 2013; Hickman et al., 2011; V. A. W. J. Marchau et al., 2003; Tuominen et al., 2014), interviews and Delphi surveys.

In transport research using the backcasting process, policy packaging has often been utilized as a means of developing policy pathways to reach the desired future vision (Åkerman et al., 2006; Banister et al., 2013; Hickman et al., 2011; Hickman et al., 2007; Julio A. Soria-Lara et al., 2018; Tuominen et al., 2014). The concept of policy packaging proves to be more effective than the use of individual policy measures and a promising approach for the policy making process. The advantage of such approach hinges on the fact that a combination of different policy measures improves the impacts of the individual measures, minimises possible negative side effects and facilitates measure implementation and acceptability (Optic Consortium, 2010).

The method for the transition phase of the backcasting exercise was initially designed around a stakeholder face-to-face workshop where the participants could engage in discussion about which policies and what time-frames would yield the transport future visions (Banister et al., 2013; Tuominen et al., 2014). However, the onset of the COVID-19 pandemic in 2020 meant that workshops where stakeholders would be physically present could not be organized. For this reason, the methodology was changed to a survey method of data collection. The method chosen is based on similar backcasting studies in transport research (Julio Soria-Lara et al., 2018; Tuominen et al., 2014). The first step consisted in identifying a range of policy measures that could yield the visions which were set in the visioning phase. For this step, a comprehensive review of academic articles, policy papers and experiences from transport practices was carried out as a desk exercise to map potential policy measures. The list of identified policies and their sources will be presented in the results Chapter 8, Section 8.3.1. The key criteria considered during the selection process were i) the potential of the measures at reducing emissions from the transport sector and achieving the 2050 alternative transport futures, ii) their influence on all three elements of mobility practices. The list of policies included a wide range of options ranging from greener technologies, infrastructure and spatial planning, attractive public transport options and pricing policies (Thaller et al., 2021).

The stakeholders who participated in the visioning workshop were again invited to be part of the transition phase. The major advantage of this approach is that these stakeholders were previously involved in the process and were already familiar with the topic and more valuable outcomes could be gathered. From the twenty-one (21) participants who were involved in the visioning workshop, fourteen (14) agreed to further participate in the survey – a response of 66%. These participants were tasked with developing pathways for each of the three future scenarios developed in the previous phases of the backcasting study. The survey was performed using the online platform Google forms. This survey can be found in Appendix E.

The first part of the survey consisted in an introduction and included the narrative of the transport future scenario for which the policy pathways needed to be designed. The second section of the survey provided the participants with the list of policies identified by the researcher in the desk exercise. Through the survey, the participants were also guided to propose further policies that would address the material, competencies and meanings of the current mobility practices. A similar approach has been adopted in guiding the transition workshop on sustainable household heating which similarly to this research was underpinned by a practice theoretical perspective (Doyle et al., 2013).

This step yielded a set of interventions which the participants then clustered into complimentary policy packages. In devising policy packages, the participants were guided to cluster policies based on their similarity, to include measures that are likely to work well together and to group together measures that might create positive synergies (Julio Soria-Lara et al., 2018).

Following the input by the stakeholder, the data was downloaded to an excel sheet for further processing and analysis. The data was first clustered into a set of proposed actions. The clustering process was based on similarities between the stakeholders' responses and the way in which the stakeholders packaged different policies together (Brovarone et al., 2021). The result of this clustering exercise was a set of policy packages for each of the three alternative transport futures.

***Semi-structured Interviews***

To compliment the survey, a set of semi-structured interviews were conducted with selected experts in the field of transport. The objective of these interviews was to further develop the policy pathways which were designed by the stakeholders through the online surveys. While workshops and focus group discussions are the preferred methods used for backcasting analysis (Carlsson-Kanyama et al., 2008), semi-structured interviews have been used in the policy pathway development phase of a number of backcasting studies (Eames et al., 2011; Höjer et al., 2011; Quist et al., 2011; Julio Soria-Lara et al., 2018; Zimmermann et al., 2012a). Individual interviews, similar to workshops and focus groups, are useful for backcasting projects. Both methods of stakeholder engagement can provide material and information of equivalent depth. Additionally, both approaches are appropriate for subjects that might involve conflict since they give the researcher the chance to directly query content that might be in conflict (Zimmermann et al., 2012a). However, interviews also provide a number of advantages over stakeholder workshops. This method of stakeholder engagement is more suited for close examinations of the views of individual participants (Jan AGM Van Dijk, 1990). In comparison, during a workshop some groups may dominate the discussion with their views and suppress the opinions of individuals (Morgan et al., 1998). Secondly, the intimate setting of the interview makes it more likely to obtain confidential information from the participants which may not be disclosed in group settings (Stokes et al., 2006). In addition, while interviews are known to be appropriate for generating similar type of in-depth data as workshops or focus groups, however, individual interviews require much less time and effort to generate the data (Guest et al., 2017). The use of semi-structured interviews are an efficient means to develop measures and pathways in the backcasting exercise.

The choice of the stakeholders for the semi-structured interviews was such as to further develop the initial results of the survey. The stakeholders for the semi-structured interviews were chosen to represent groups of stakeholders which were not represented amongst the fourteen (14) stakeholders who participated in the policy packaging survey. Table 4.10 presents a summary of the experts who participated in the semi-structured interviews.

**Table 4.10: List of interviewees for transition phase**

| Stakeholder | Type of expertise |
|---|---|
| Transport Expert | Geographer and transport planner |
| Transport Expert 2 | Urban and transport planner |
| Policy maker | Local government |
| NGO on transport | Bicycle advocacy group (Rota) |

The semi-structured interviews were carried out between February and March 2021. Due to social distancing measures which were in-place as a result of the pandemic, all interviews were conducted online using the platform Zoom (www.zoom.com). The interviews lasted between one and two hours. The interview schedule which was used to guide the semi-structured interviews can be found in Appendix F.

During the online meetings, the stakeholders were first introduced to the aims and objectives of the research and guided through the different phases. Interview participants were informed about the purpose of the study and were asked to sign a consent form prior to the interview, to give permission to be audio-recorded, and for the information provided to be used in the research. They were then presented with the narratives of the transport future scenarios which were developed during the visioning phase of the process. The participants were also provided with data from the outcomes of the stakeholder survey. This included a set of policy packages which in the opinion of the participants of the policy packaging survey have the potential of delivering the alternative transport futures designed during the visioning phase. The next step involved the researcher asking each of the interviewees a set of questions, following a pre-defined interview guide, with the aim of guiding them into developing a set of policies and implementation pathways for the alternative transport futures.

The questions included the following:

i) What interventions can help achieve this scenario?

ii) How can these interventions be combined with other policies that help to increase their effectiveness, acceptability, and feasibility?

iii) What time frames should be used for their implementation? (Short-term 2021-2030; Medium-term 2030-2040; Long-term 2040-2050).

iv) Who are the key actors for implementation? (Local governance, national government?)

Following the interviews with the experts, the data gathered was further elaborated into concrete policy pathways. This stage was carried out as a desk exercise. The interview data, which was collected as audio-recorded data, was first transcribed into usable transcripts. The transcripts were then subjected to qualitative analysis (Bryman, 2016) using an inductive approach. This involved an iterative coding process, where themes in the data which refer to policies and policy pathways were identified and subsequently reworked and refined. These themes were refined into concrete policy pathways for each of the three alternative future scenarios. The end results of the qualitative exercise was a set of policies and their implementation time frames from the year 2018 to the year 2050 for each of the three alternative future scenarios.

### 4.8.2 Citizen insight and refinement of transition pathways

The final stage of the research consisted in the refinement of the policy pathways developed from the stakeholder engagement sessions. This further elaboration of the policies was possible by incorporating citizens' opinions and ideas in the backcasting process. This section of the methodology is part of the transition phase of the backcasting process and aims to answer the fourth research question; *What policy implementation pathways can be developed to meet the sustainable mobility practices?*

One advantage of incorporating citizens' opinion in policy development is that more agreement and consensus can be reached on what policies are required for transition to more sustainable mobility. It is well-known that lack of public support is often a major barrier to the transition to a low-carbon economy (Geels, 2013, Wiseman et al., 2013). Creating public acceptability for sustainable mobility measures helps the implementability of transport policies and can even lead to change in behaviours (Banister, 2008). This phase of the research again adopts the Theory of Social Practice as the guiding framework. This section of the methodology will describe the methods of data collection that integrate citizen participation in the backcasting process.

The methodology chosen for this phase of the research has two purposes:

i) collect data on the acceptability and implementability of transport climate polices developed during the earlier phases of the process;
ii) refine the policy pathways developed in the previous phases.

The collection of information about individuals' perceptions to climate policy and the impact of such policies on the citizens' daily-life is complex and necessitates tools that would be able to capture such complexity. Qualitative methods of analysis are powerful tools that can address complex subjects and allow the capture of the individual's own experiences and attitudes (Flick, 2014; Clifton and Handy, 2015). These types of methods are increasingly being applied in transport research where the focus is on the subjective experience related to mobility of the individuals. These qualitative methods of analysis are often used on their own or together with other quantitative techniques as multidisciplinary parts of wider studies (Grosvenor, 2000).

There is a range of tools available which can be utilised to engage citizens in transport planning. The choice of these tools reflects the level of citizen engagement required and the aim for public participation in the planning process. Choosing the right tools for citizen involvement is not easy and the correct tools will influence the effectiveness of the process, the level of participation and the quality of the results. A number of factors could influence the choice of participation tools, these including the type of citizens that will be involved, the time frame and duration of involvement and the type of project (Lindenau et al., 2014). Workshops have been often applied as a tool for citizen involvement for the planning of sustainable transport. For example, workshops have been extensively used in European countries as part of complex planning process (May, 2016; Gil et al., 2011). This qualitative method has also been demonstrated to be suitable for determining the public's reaction to proposals for private vehicle use through diverse demand management measures and toll systems (Loukopoulos et al., 2005). Workshops offer an advantage over other qualitative techniques such as interviews or questionnaires by allowing for group interactions and providing greater insight into why certain beliefs and opinions are held. Through the interaction between participants, these interactive methods of citizen involvement encourage more critical thinking during the planning process (Loukopoulos et al., 2005).

This study was based on a workshop methodology for engaging the citizens into reviewing the policy pathways established in the previous phases of the study and providing their subjective ideas on how these pathways affect their day-to-day activities and contributing to refining the policy pathways. At the time for which the citizen engagement workshop was scheduled, several measures related to the pandemic which imposed social distancing and limited group numbers were still in place. This situation meant that the workshop could not be held face-to-face and for this reason, the interactive exercise was shifted to an online environment. Once again, the online video conferencing tool *Zoom* (https://zoom.us/), was used to bring the participants together for discussion on the impact and acceptability of the policy pathways for future transport visions. The next section will describe the approach and various steps used during the workshop.

***Participant selection and invitation***

A snowballing technique was employed to recruit participants for the citizen workshop. A number of potential participants were first identified and then invited to participate in the workshop. The target participants were members of the public with a concern on sustainable mobility and interested in contributing towards transport climate policy. This method of participant recruitment is a non-probability sampling technique where the sampled population is not intended to be representative of the general population. An initial set of participants were sent an invitation for participation in the workshop, these individuals were also asked to refer this invitation to other citizens who might also be interested to be part of the public participation workshop. In addition to the snowballing technique, participants were also recruited through an advertising campaign on social media. A total of 13 citizens showed their interest, however 10 participants attended the workshop.

***Citizen Workshop***

The interactive citizen participation exercise took the form of a two-hour workshop which was based online, and which took place on the 20th July 2021. After an initial ice-breaking session, the participants were introduced to the research topic and given an overview of their role in the project and the importance of their contribution. During the introductory session, the participants were also informed about the aim of the project and introduced to the backcasting methodology. The researcher also ensured that the participants familiarised themselves well with the Theory of Social Practice.

Following the introduction, the researcher then presented the future visions created during the earlier phases of the study. During this part of the workshop, the salient points of each future were presented, ensuring that the information provided was appropriate and could be easily comprehended by the citizens participating in the workshop. The participants were then provided with an overview of the policies which the stakeholders envisaged as fit for reaching the desired future visions.

The interactive session of the workshop, where citizens could provide their input, was mediate by an online tool. This tool, Ahaslides (www.ahaslides.com), is based on the same concepts of Mentimeter which was utilised during the visioning workshop. It is a real-time online application that allows the participants to answer questions and provide personal views and discussions through a device which is connected to the internet (such as mobile phone, laptop or tablet). The application allows the participants to view the responses submitted in real-time hence promoting interaction between participants and enhancing group discussion.

During this interactive session, each of the policy measures designed by the stakeholders in the earlier stages for each of the alternative future vision was discussed. The participants were then asked to answer the following question for each policy: *If this policy is implemented, what changes do you foresee to your daily practices and activities?* A two-minute time-frame was allowed for the participants to provide their input for each of the policy measures. This time-frame also allowed the participants to ask questions and request further clarification on the policies where they felt that more information was required. The responses submitted were shown on-screen in real-time and were also recorded on the online application for download after the workshop. In their answers, the participants included a range of different concepts about the ways in which the policies would influence their day-to-day activities and their social practices (Figure 4.8).

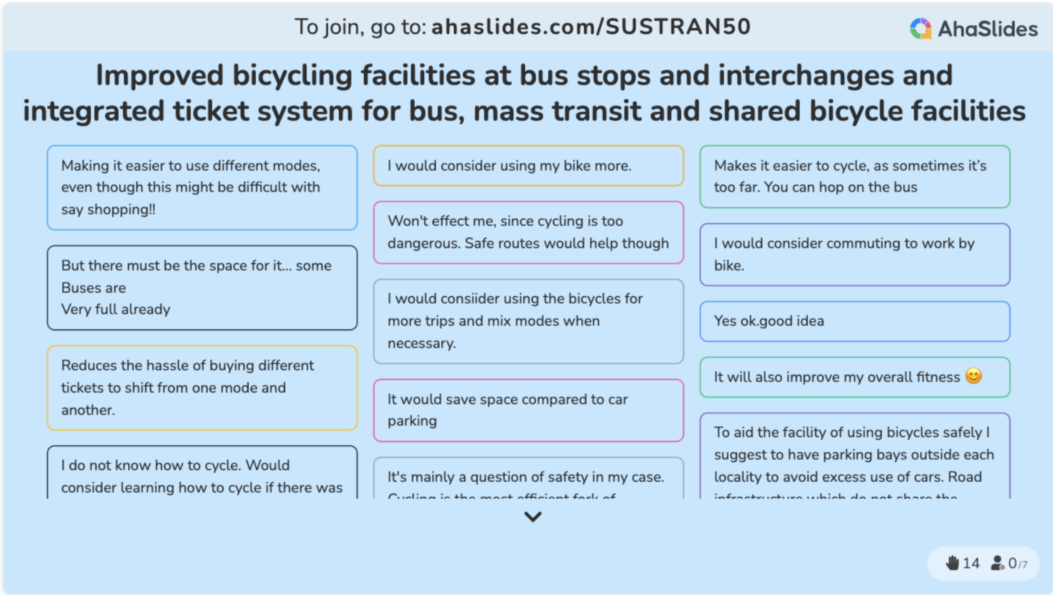
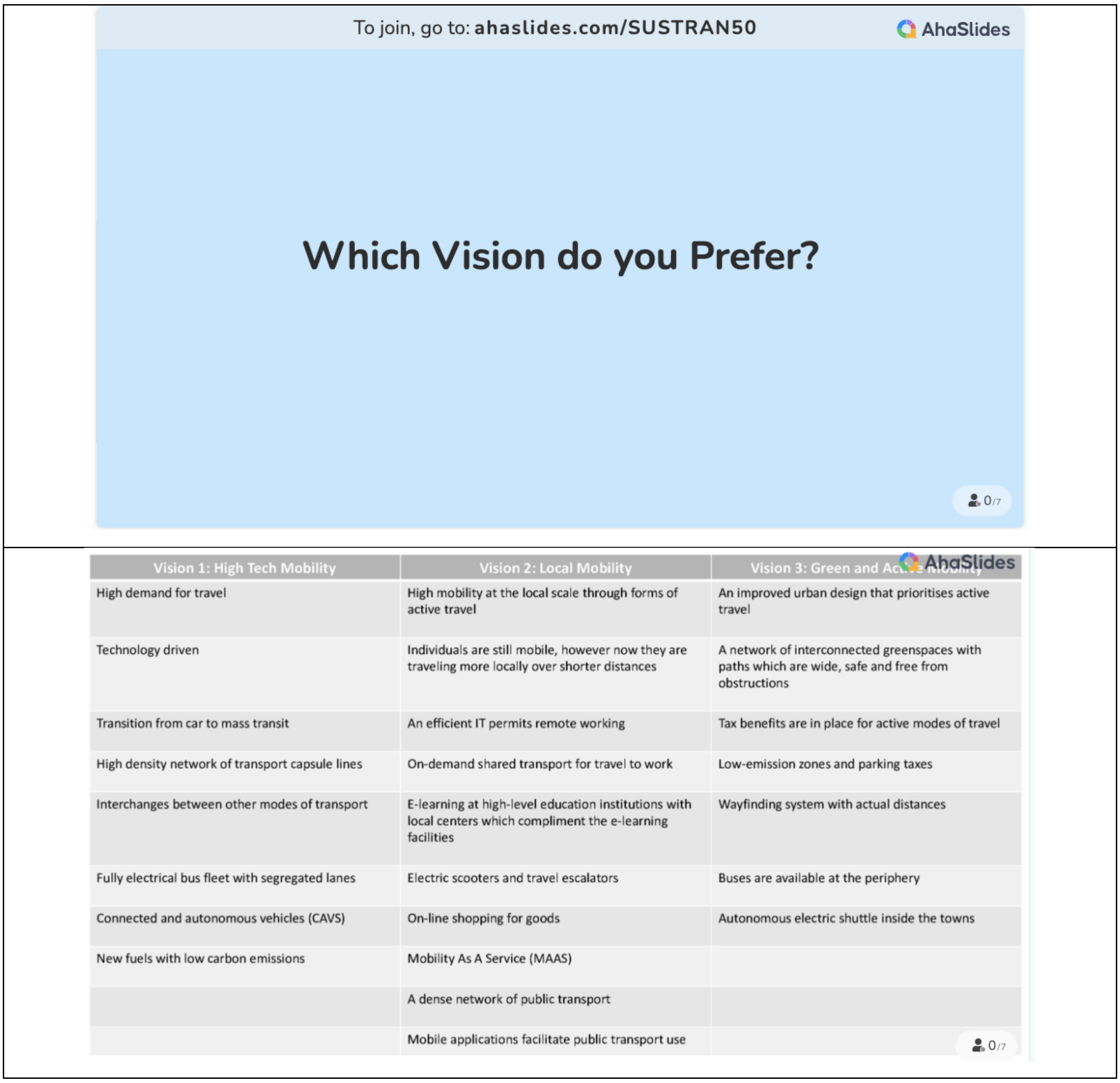



**Figure 4.8: Citizens' opinion for different policy measures.**

The next step of the citizen workshop was characterised by a voting exercise where the citizens were asked to choose their preferred vision for the transport in Malta in 2050, as established by the stakeholders during the visioning phase of backcasting. To aid the participants in this task, the researcher provided the main highlights of each of the future visions side-by-side. Through this presentation, the participants could have a comparative overview of the different transport visions. The citizens involved in the workshop where then invited to vote for their preferred vision through the online application (Ahaslides) (Figure 4.9). The participants were invited to base their decision on the way each future vision would impact their day-to-day activities. The results were again shown in real-time.

After the voting exercise, the participants were guided to design policies and implementation time-frames which in their opinion would be required to attain the preferred vision. The policies for the preferred vision were designed around three timeframes namely; the short-term (2021-2030), medium-term (2030-2040) and the long-term (2040 -2050). During this exercise, the research team prompted the participants to think of policies that bring together all the elements (materials, competencies and meanings) of sustainable mobility practices. To do this, the researcher illustrated some examples of policies adopted in other contexts that target the different elements of mobility practices. The participants were also encouraged to think of policies outside the transport sector and include measures which are aimed at other spheres of social life (such as work, shopping and parenting) which have an influence on how people travel. This step of the workshop which took place in the form of a discussion, with the researcher acting as a moderator, provided an opportunity for the participants to interact together to discuss similar and divergent ideas to finally reach a consensus on the policy pathways required to attain the future transport visions.




| Vision 1: High Tech Mobility | Vision 2: Local Mobility | Vision 3: Green and Ac |
|---|---|---|
| High demand for travel | High mobility at the local scale through forms of active travel | An improved urban design that prioritises active travel |
| Technology driven | Individuals are still mobile, however now they are traveling more locally over shorter distances | A network of interconnected greenspaces with paths which are wide, safe and free from obstructions |
| Transition from car to mass transit | An efficient IT permits remote working | Tax benefits are in place for active modes of travel |
| High density network of transport capsule lines | On-demand shared transport for travel to work | Low-emission zones and parking taxes |
| Interchanges between other modes of transport | E-learning at high-level education institutions with local centers which compliment the e-learning facilities | Wayfinding system with actual distances |
| Fully electrical bus fleet with segregated lanes | Electric scooters and travel escalators | Buses are available at the periphery |
| Connected and autonomous vehicles (CAVS) | On-line shopping for goods | Autonomous electric shuttle inside the towns |
| New fuels with low carbon emissions | Mobility As A Service (MAAS) | |
| | A dense network of public transport | |
| | Mobile applications facilitate public transport use | |

**Figure 4.9: Snapshots from the online Citizen workshop during the voting exercise**

### *Data analysis of the Citizen workshop*

The input provided by the participants during the interactive session was recorded through the Ahaslides, a web-based application. After the workshop this data was downloaded and analysed. The data gathered during the interactive session consisted of individual statements for each of the policy measures showing their influence on the daily social practices that the citizens participating in the workshop engage in. These statements represent the participants' response to different types of policies as shown in Table 4.11 as an example.

**Table 4.11: Examples of citizens' responses**

| *If a policy which sees the management of parking and traffic in towns is implemented, what changes do you foresee to your daily practices or activities?* | |
|---|---|
| **Response** | **Statement** |
| 1 | Might be too slow for daily commuting |
| 2 | Would be great for not driving yourself |
| 3 | Increased safety on the roads and greater efficiency. Less cars will be needed. |
| 4 | It may be an issue if someone has a disability |
| 5 | For management of parking, local town planning has to change. Private cars are not to be parked exclusively in residential garages. Parking lots/bays are to be introduced outside the locality. Walking and bicycles are to be encouraged as sole means of mobility. |
| 6 | Might encourage better use of parking spaces in terms of time. |
| 7 | It may increase my house value due to decrease in traffic |
| 8 | May cause some issues for residents living in that town |
| 9 | I would walk more and use a foldable bicycle to put in my vehicle and park the car outside the inner core areas so I can access the inner core without a vehicle. On some days I would opt to pay more for parking if I can access the centre without having to walk or use the bicycle, weather permitting. |
| 10 | It may be an issue for the elderly, as they may not be able to walk and carry materials |
| 11 | It would diminish pollution in towns |
| 12 | Would consider taking the bus |
| 13 | Less traffic from cars searching for a parking spot. |
| 14 | It would force me to rethink my travels to park outside of the town and walk |
| 15 | If I can find a parking more<br>Efficiently it makes going there easier by car |
| 16 | I would think twice about using my personal car. |
| 17 | I think it's a good idea. A little like the Park and Ride |
| 18 | Walking would be safer and more enjoyable. |
| 19 | This might affect how many times I go into managed areas. |
| 20 | It would make town centres more social |
| 21 | It depends how much it costs |
| 22 | It could also be useful if I can find parking - deters others |
| 23 | This could me that I don't travel by car to some town centres |

The data was analysed using both quantitative and qualitative methods of analysis. The responses were first analysed by the researcher quantitatively. For each of the policy options, the statements the participants inputted were classified into two groups. The first group represented those statements in which the participants said that the policy measure would not hinder or have a negative impact on their day-to-day mobility needs. On the other hand, the other group represented those statements where the participants said that the policy option would make it difficult for them to attend to their day-to-day activities. Following this classification, an index showing the degree of positive responses was calculated for each of the policies. The index was calculated as follows:

Index = Number of positive responses / number of total responses

The data recorded during the workshop was also analysed qualitatively, using the Theory of Social Practice as the guiding framework. The three-element model of social practices as proposed by Shove et al., (2012) was used to guide the thematic analysis. During this qualitative analysis, the statement gathered collected from the citizens' were examined for the occurrence of reference to the elements (materials, competencies and meanings) of the mobility practices as the basis for creating themes and codes during the analysis. The aim of the qualitative analysis was to uncover those elements of sustainable mobility practices which the citizens believe were not addressed through the policy pathways.

## 4.9 Conclusion

This chapter has focused on presenting the research design, the methods of data collection and the tools and techniques used for analysing the data collected to produce interpretable information. This section summarises the main points of the research design, the methods of collecting and analysing the data. This study aims to address the gaps in research by focusing on building on the existing knowledge in transport research that adopt a practice-based approach. The choice of the theoretical framework and research methods reflect this aim. The research presents methodological innovations by developing and assessing the effectiveness of alternative mobility practice reconfigurations. To enable this, the research integrates the social practices theoretical framework with a backcasting process. To test this innovative approach, the case study of Malta was adopted.

The chapter started with an overview of the research aim, objectives of the study and the research questions. The chapter also described how the research questions were addressed through the chosen data collection and analysis techniques. The case-study empirical research was based on a mixed-methodology approach which included surveys and interviews to characterise the current transport situation and identify the current mobility practices. The data of this initial step then fed into a backcasting process which involved workshops with stakeholders to establish desired transport visions, development of alternative scenarios during a desk-exercise, assessment of the scenarios through modelling techniques and designing of policy pathways through the engagement with stakeholders and citizens. The tools for analysing the data include descriptive statistics and thematic analysis of the interviews to generate information on the current situation. Qualitative analysis was also employed to analyse data generated from workshops and participatory methods of stakeholder and citizen involvement. Quantitative modelling tools were used to estimate the emission reduction potential of different transport future scenarios.

The chapters which follow present the results of the data collection and analysis. The current mobility practices and other social practices influencing mobility, will be presented in Chapter 5. The results of the visioning workshop and the alternative transport future scenarios will be presented in Chapter 6. Chapter 7 will provide an overview of the assessment of the alternative future scenarios against the emission reduction targets set for this study. The policy pathways through which the alternative scenarios may be attained will be presented in Chapter 8.

# Chapter 5: Mobility practices in Malta

*Part of the results of this chapter have been published in a journal article:*
*Camilleri, R., Attard, M., & Hickman, R. (2022). Understanding barriers to modal shift in Malta: A practice-theoretical perspective of everyday mobility, Journal of Transport Geography, Volume 104, 103446.*

## 5.1 Introduction

This chapter seeks to understand the current mobility practices which characterise the transport system in Malta. This chapter covers the second objective of the research and answers the first research question; *What are the current types of mobility practices in Malta?* To answer this question, a mixed methodology approach was adopted which combines both quantitative and qualitative methods of data enquiry. A travel survey was employed to gather data on the types of mobility, while semi-structured interviews were used to explore in more depth these mobility practices and how they are shaped by other social practices.

The chapter is divided into two parts. The first part (Section 5.2) presents the quantitative analysis of the travel survey. The results from the travel survey will provide an understanding of the types of mobility practices that individuals in Malta engage with during their daily lives and reveal the prevalent types of mobility. The results will also uncover which other social practices interact with mobility and influence mode choice. The second part of the Chapter (Section 5.3) then, presents the results of the semi-structured interviews. The qualitative analysis allows for a more in-depth understanding of the constituent elements of mobility practices and how the availability or lack of these elements influence the prevalence of mobility practices and not others. The qualitative analysis will also reveal how other social practices influence the recruitment to different forms of mobility practices.

## 5.2 Types of mobility practices

To understand the types of mobility practices in Malta and identify other social practices which influence mode choice, descriptive statics were used to analyse the data collected through the travel survey.  Descriptive statistics, or simply statistics, are useful to estimate characteristics of a population (Nick, 2007). This section provides a summary of the key descriptive statistics for the data collected though the travel survey.

### 5.2.1 Demographic characteristics of the sampled population

First, a summary of the characteristics of the participants of the study grouped by age, gender and district is illustrated in Table 5.1.

**Table 5.1: Characteristics of the sampled population**

| | | District | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Age** | **Gender** | **Gozo** | **Northern** | **Northern Harbour** | **South Eastern** | **Southern Harbour** | **Western** | **Total** |
| 0 - 19 | Female | 1 | 3 | 6 | 5 | 1 | 1 | 17 |
| | Male | | 1 | 2 | 2 | | 1 | 6 |
| 20 - 39 | Female | 2 | 15 | 36 | 17 | 11 | 20 | 101 |
| | Male | 3 | 17 | 22 | 11 | 5 | 7 | 63 |
| 40 - 59 | Female | 3 | 16 | 35 | 17 | 16 | 15 | 102 |
| | Male | 2 | 4 | 15 | 7 | 4 | 6 | 37 |
| 60+ | Female | 3 | 9 | 16 | 9 | 6 | 9 | 52 |
| | Male | 3 | 4 | 4 | 4 | 2 | 2 | 19 |
| Total | | 17 | 69 | 136 | 72 | 45 | 61 | 400 |

The distribution of the participants by age and district is represented in graphical form in Figure 5.1, which also shows the distribution of the general population in Malta. Such a comparison allows for an analysis of the representativeness of the sampled population relative to the general population. Figure 5.1 shows similar distributions for both the sampled and the general population. In the sampled population, the age range 0-19 is generally underrepresented when compared to the distribution of the general population. This bias may have been introduced as a result of the use of an online survey as the method of data collection (Bethlehem, 2010).

Descriptive statistics were generated to further describe the sampled population. These include data on the nationality of the individuals, the type of employment and education level of the participants. Most of the survey participants (83.3 %) were of Maltese nationality with the reminder of the sampled population being of other nationalities (which currently makes up approximately 10% of the islands' population). The respondents of the survey demonstrated a range of occupations and lifestyles from participants having a professional occupation, administrative roles and students to self-employed individuals and stay-at-home care givers. The participants also show a wide range of education levels with the highest (30%) having completed postgraduate level of education. The high incidence of respondents with postgraduate level of education may be the result of self-selection bias which was introduced by the use of online survey tool (Bethlehem, 2010). The variability in participant demographics variability in the data is important for the study as it represent different lifestyles and variability in the day-to-day life of the respondents. This is significant for the study which aims to determine how different social practices influences mobility.

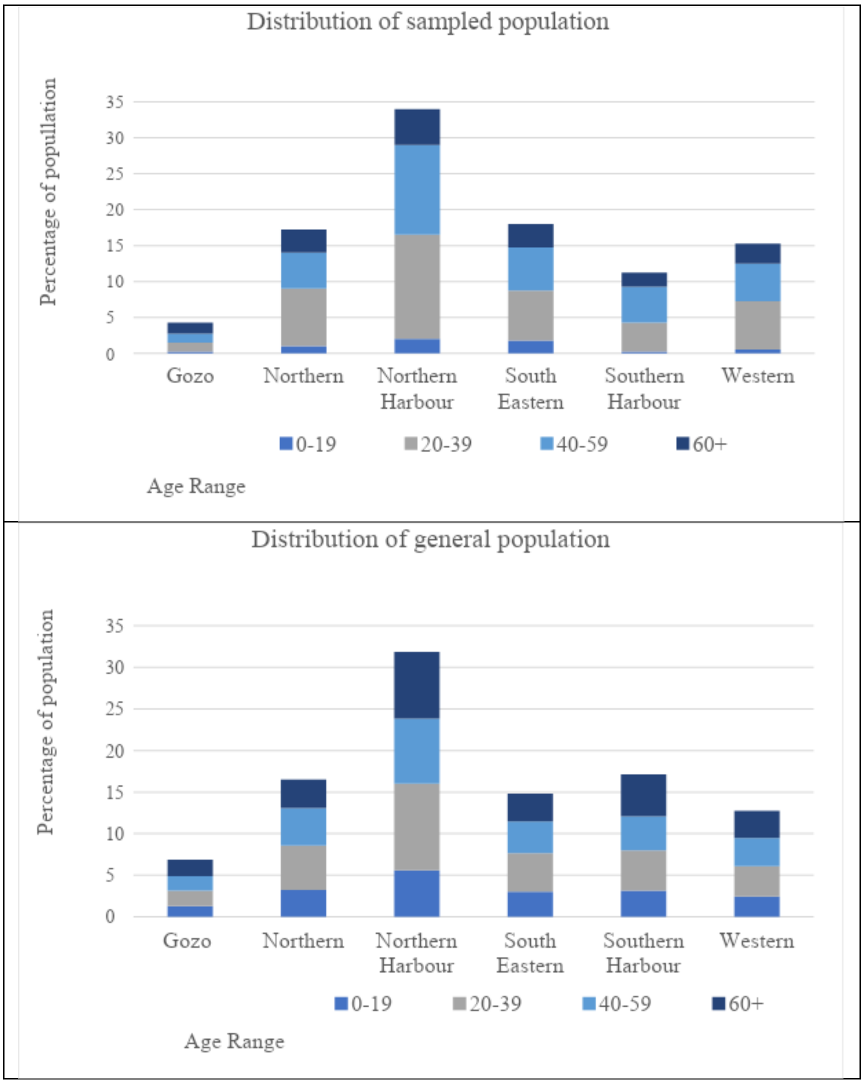



**Figure 5.1: Comparison of the sampled and general population**

### 5.2.2 Mode choice and access to personal transport modes

During the survey, participants were asked about their preferred mode of travel. The survey results demonstrate how amongst the sampled population, the car is by far the most preferred mode, with 73% of the participants listing this mode of transport as their preferred way of travelling (Figure 5.2). The preference for public transport use was low within the sampled population, with 13% of the respondents stating they prefer the bus for their travels. Preference for active modes of travel such as walking and cycling was low in the sampled population, with only 9% of the total participants saying they make use of such modes for travelling.

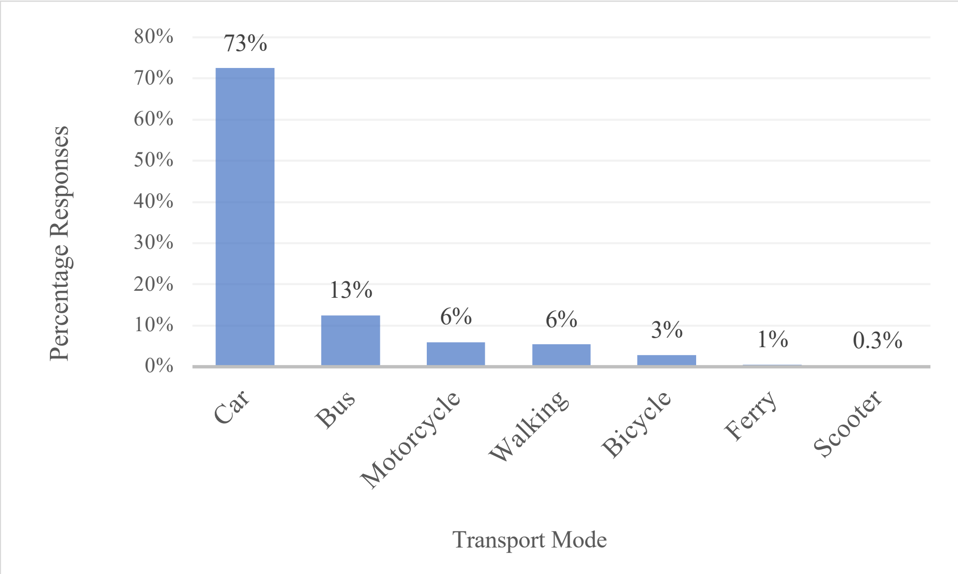



**Figure 5.2: Preferred mode of travel**

When the respondents were asked if they own any means of transport, most of the participants answered that they own a private car (Figure 5.3). Of these 69% answered that they only own a private car as a means of transport, whilst the remaining (23%) stated that they own another means of transport, such as a bicycle or a motorcycle, in addition to the car. Of the participants, 1.5% included an electric car as their owned means of transport and 24% of the survey participants said that they own a bicycle as one of the means of transport. Only 3% of all participants said that they only own a bicycle as means of transport. Figure 5.1 also demonstrates differences between the male and female sections of the population. A higher percentage of males reported that they own a car when compared to car-ownership amongst females. In contrast, a higher percentage amongst the males own a bicycle or a motorcycle when compared to females.

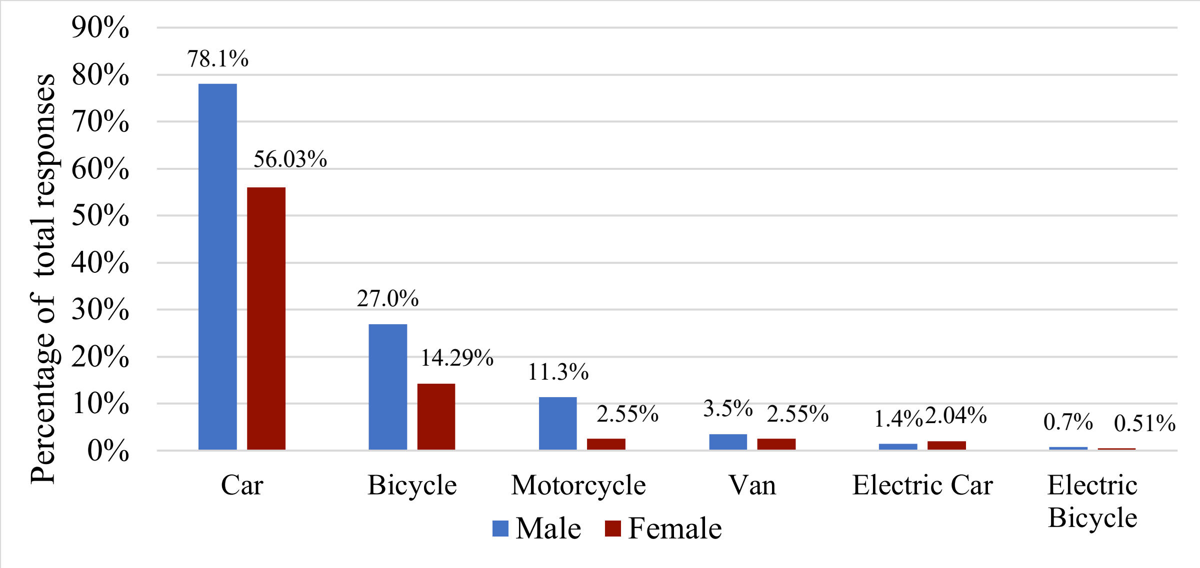



**Figure 5.3: Ownership of different means of transport**

### 5.2.3 Trip Purposes

The participants were asked to list the purpose of the trips they performed during their typical weekday and a day during the weekend. The aggregated data showing the main travel purposes is summarised in Table 5.2. The table shows the that the most common trip purposes include travelling to the place of work and visiting someone. Travelling to reach sites of education, leisure activities and shopping were also amongst the top reasons why individuals travelled.

The significance of this data for this study is not only to show the purpose of why individuals chose to travel, but serves to illustrate those social practices for which the demand for mobility is created. What the data is showing is that working, visiting someone, education, participating in leisure activities and shopping are amongst the social practices which make up the daily lives of the individuals. Other social practices which influence mobility practices include, travelling with children, eating out, shopping for food, community activities, travelling for business or for medical visits.

**Table 5.2: Trip purposes**

| Activity at Destination | Percentage of trips |
|---|---|
| Home | 22.7 |
| Place of Work | 20.0 |
| Visit someone | 10.2 |
| Education | 6.6 |
| Other Leisure Activity | 6.5 |
| Other | 6.1 |
| Shopping | 5.1 |
| Sport | 4.9 |
| Accompany a child | 4.6 |
| Eat out | 4.6 |
| Shop for food | 4.3 |
| Community activities (e.g. religious, voluntary work) | 2.6 |
| Business | 1.1 |
| Medical visit | 0.9 |
| **Total** | **100.0** |

### 5.2.4 Trip Purpose and Mode choice

Mobility practices do not exist on their own but are bundled with and influenced by other social practices which create the demand for travel. When individuals engage in these social practices, they chose different forms of mobility practices to travel to the site of these activities. To investigate if there is any association between trip purpose and mode choice, the Chi-Square test was used. The Chi-Square test assesses the relationship between two categorical variables. The null hypothesis specifies that there is no association between the two variables and is accepted if the p value exceeds the 0.05 level of significance. The alternative hypothesis specifies that there is a significant association between the two categorical variables and is accepted if the p value is less than the 0.05 criterion. The results of the Chi-squared tests are given in Table 5.3. These results show that since the p-value was less than the 0.05, the null hypothesis was rejected thus showing there is an association between the trip purpose and mode choice.

This association between mode choice and different social practices can be further explained from the results in Table 5.4. For example, most of the trips made for the purpose of accompanying a child are done using the car and only a small percentage of trips are made with the bus or on foot. Similarly, the table shows that trips made to the place of work are mostly done by car. Social practices including participating in sports, attending to business matters, visiting someone and shopping for food also show high usage of the car as a means of travel.

**Table 5.3: Association between mode choice and trip purpose**

| | Value | df | Asymptotic Significance (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 244.604 | 104 | <.001 |
| Likelihood Ratio | 237.954 | 104 | <.001 |
| Linear-by-Linear Association | 5.175 | 1 | .023 |
| N of Valid Cases | 1388 | | |

$X^2(104) = 230.19$, $p < 0.001$

**Table 5.4: Mode Choice by type of activity at destination**

| Activity at Destination | Percentage Mode Choice | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Car driver | Car passenger | Bus | Minibus / Coach | Motorcycle | Ferry | Walk | Bicycle | Taxi |
| Accompany a child | 84.4 | 9.4 | 1.6 | 0.0 | 0.0 | 0.0 | 4.7 | 0.0 | 0.0 |
| Place of Work | 68.7 | 4.0 | 12.2 | 0.0 | 6.1 | 0.0 | 5.8 | 2.9 | 0.4 |
| Sport | 63.2 | 10.3 | 4.4 | 0.0 | 4.4 | 0.0 | 13.2 | 4.4 | 0.0 |
| Business | 62.5 | 25.0 | 12.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Visit someone | 54.9 | 22.5 | 12.7 | 0.0 | 2.8 | 0.0 | 4.2 | 1.4 | 1.4 |
| Home | 53.2 | 17.1 | 11.4 | 0.3 | 5.4 | 0.0 | 10.4 | 1.9 | 0.3 |
| Shop for food | 51.7 | 16.7 | 6.7 | 0.0 | 1.7 | 0.0 | 23.3 | 0.0 | 0.0 |
| Medical visit | 50.0 | 33.3 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Other Leisure Activity | 49.5 | 20.9 | 8.8 | 0.0 | 7.7 | 0.0 | 8.8 | 3.3 | 1.1 |
| Shopping | 45.1 | 19.7 | 19.7 | 0.0 | 8.5 | 0.0 | 7.0 | 0.0 | 0.0 |
| Other | 43.2 | 25.9 | 18.5 | 1.2 | 2.5 | 0.0 | 6.2 | 1.2 | 1.2 |
| Community activities | 38.9 | 25.0 | 19.4 | 0.0 | 2.8 | 2.8 | 11.1 | 0.0 | 0.0 |
| Education | 38.2 | 20.2 | 27.0 | 0.0 | 2.2 | 0.0 | 10.1 | 2.2 | 0.0 |
| Eat out | 34.4 | 43.8 | 9.4 | 0.0 | 0.0 | 1.6 | 9.4 | 0.0 | 1.6 |

Table 5.4 reveals how some social practices are more dependent on the car than others. To illustrate this dependency, a graph showing percentage of trips made by car for each type of activity was plotted (Figure 5.4). The graph shows that accompanying a child is the most car dependent of the social practices which the respondents described during the survey. Commuting, participation in sport and business activities also scored high amongst the practices showing high car dependence. On the other hand, participation in community activities, education and eating out scored lowest on the scale of car dependence.

**Figure 5.4: Car dependence and social practices**

### 5.2.5 Factors influencing mode choice

Whilst the Chi squared test was useful to show the relationship between mode choice and activity at destination, it has one major limitation. This type of statistical investigates solely the relationship / association between two variables one of which includes the mode of transport. However, it is also important to analyse all the variables that contribute to the observed mode choice together. To overcome this limitation the multinomial logistic regression model was used to relate the mode of transport (dependent) to all the other variables collectively (predictors).

Table 5.5 shows the independent variables which were used in the multinomial logistic regression model to analyse the influence on mode choice. The table provides a description of these variables and a summary of the categories for each of the independent variables.

**Table 5.5: Variables used in multinomial logistic regression model**

| Variable | Description | Categories |
|---|---|---|
| Trip Duration | Duration of the recorded trip | Minutes (discrete) |
| Age-group | Age of the respondent | <30; 31-40; 4-50; 50+ (nominal) |
| Gender | Gender of the respondent | Male; Female (nominal) |
| Nationality | Nationality of the respondent | Maltese; non-Maltese (nominal) |
| Employment | Type of employment of the respondent | Senior management; management; executive; professional; vocational; technicians; administrative roles; skilled worker / tradesperson; stay-at-home worker; student; unemployed; self-employed; researcher; sales and services; retired (nominal) |
| Children | Respondent has children | Yes; No (nominal) |
| Trip type | Trip preformed on weekday or weekend | Weekday; Weekend (nominal) |
| Trip Start | Region where trip was started | Southern Harbour; Northern Harbour; South-eastern; Western; Northern; Gozo (nominal) |
| Activity at Destination | The activity for which the trip was taken | Accompany a child; Place of Work; Sport; Business; Visit someone; Home; Shop for food; Medical visit; Other; Leisure Activity; Shopping; Other; Community activities; Education; Eat out (nominal) |
| Trip End | Region where the trip ended | Southern Harbour; Northern Harbour; South-eastern; Western; Northern; Gozo (nominal) |

The results of the multinominal logistic regression model are presented in Table 5.6. The model identifies six significant predictors which include age group, gender, nationality, children, trip end and trip type.

**Table 5.6: Multinomial Logistic Regression model**

| | Model Fitting Criteria | Likelihood Ratio Tests | | |
|---|---|---|---|---|
| Effect | -2 Log Likelihood of Reduced Model | Chi-Square | df | Sig. |
| Intercept | 3117.086 | .000 | 0 | . |
| Age-group | 3253.518 | 136.432 | 24 | <.001 |
| Gender | 3304.356 | 187.270 | 8 | <.001 |
| Nationality | 3253.790 | 136.703 | 8 | <.001 |
| Children | 3143.427 | 26.341 | 8 | <.001 |
| Trip type | 3190.641 | 73.555 | 8 | <.001 |
| Trip End | 3270.852 | 153.766 | 40 | <.001 |

p-value <0.05

Moreover, a forward procedure was used to identify the Parsimonious model which includes solely the significant predictors. The Parsimonious model includes the six significant predictors identified in the multinomial logistic regression model namely; age group, gender, nationality, children, trip end and trip type. The results of this model are presented in Table 5.7. The R squared value (0.433) indicates that this six predictor Parsimonous model explains 43.3% of the total variation in the modes of transport. This means that there are other factors which influence mode choice in addition to the six predictors identified in the model.

**Table 5.7: Parsimonious model for mode choice**

| Effect | Model Fitting Criteria | Likelihood Ratio Tests | | |
|---|---|---|---|---|
| | -2 Log Likelihood | Chi-Square | df | P-value |
| Age-group | 3254.557 | 117.905 | 24 | .000 |
| Gender | 3314.901 | 178.248 | 8 | .000 |
| Nationality | 3267.676 | 131.023 | 8 | .000 |
| Children | 3163.527 | 26.874 | 8 | .001 |
| Trip Type | 3286.502 | 149.850 | 40 | .000 |
| Trip End | 3190.641 | 53.988 | 8 | .000 |

Nagelkerke Pseudo R-Square value = 0.433

### 5.2.6 Trip Duration

The data gathered through the survey was also useful to provide information on the average time taken to move between sites of activities. The largest proportion of the total trips recorded were between 10 and 40 minutes with a mean of 30.36 minutes. Very few trips (< 5% of all trips) were above 60 minutes.

The One-way ANOVA test was used to compare mean trip duration between several modes of transport. The null hypothesis specifies that the mean trip duration varies significantly between the 9 modes of transport and is accepted if the p values exceed the 0.05 level of significance. The alternative hypothesis specifies that the mean trip duration varies significantly between the modes of transport and is accepted if the p value is less than the 0.05.

The results of the One-way ANOVA are presented in Table 5.8, which shows that the mean trip duration is largest when using the Ferry, this is followed by the bus and the bicycle. The results of this test of significance shows that mean trip duration varies significantly between different modes of transport because the p value is less than the 0.05 level of significance. The results for the mean trip duration are also illustrated in Figure 5.5, where the error bar in the graph provides the 95% confidence interval of the actual mean trip duration if the whole Maltese population had to be included in the study. The data is important to show how the bus is the least time efficient of land-transport modes, despite it being the most efficient at carrying large numbers of individuals to their destinations. This difference in travelling time between different modes of transport has been noted in other studies in the Maltese context. For example, in a study investigating mobility amongst the elderly population, journey time by bus was reported to be longer than by car (Mifsud et al., 2017). Another report states that the average morning journey time for a trip made by car is of 19 minutes while that made by bus averages to 48 minutes (Transport Malta, 2016a).

**Table 5.8: One-way ANOVA test for mean trip duration**

| | | | | 95% Confidence Interval for Mean | |
|---|---|---|---|---|---|
| **Mode of transport** | **Mean trip duration** | **Std. Deviation** | **Std. Error** | **Lower Bound** | **Upper Bound** |
| Car driver | 28.26 | 23.108 | .835 | 26.62 | 29.90 |
| Car passenger | 32.85 | 25.320 | 1.621 | 29.66 | 36.05 |
| Bus | 42.11 | 26.525 | 1.950 | 38.26 | 45.96 |
| Minibus / Coach | 29.40 | 11.696 | 5.231 | 14.88 | 43.92 |
| Motorcycle | 24.41 | 16.515 | 2.115 | 20.18 | 28.64 |
| Ferry | 78.17 | 50.788 | 14.661 | 45.90 | 110.44 |
| Walk | 27.20 | 19.827 | 1.682 | 23.88 | 30.53 |
| Bicycle | 33.73 | 34.938 | 6.852 | 19.62 | 47.84 |
| Taxi | 30.14 | 22.139 | 8.368 | 9.67 | 50.62 |

$F(8,1436) = 13.239$, $p < 0.001$

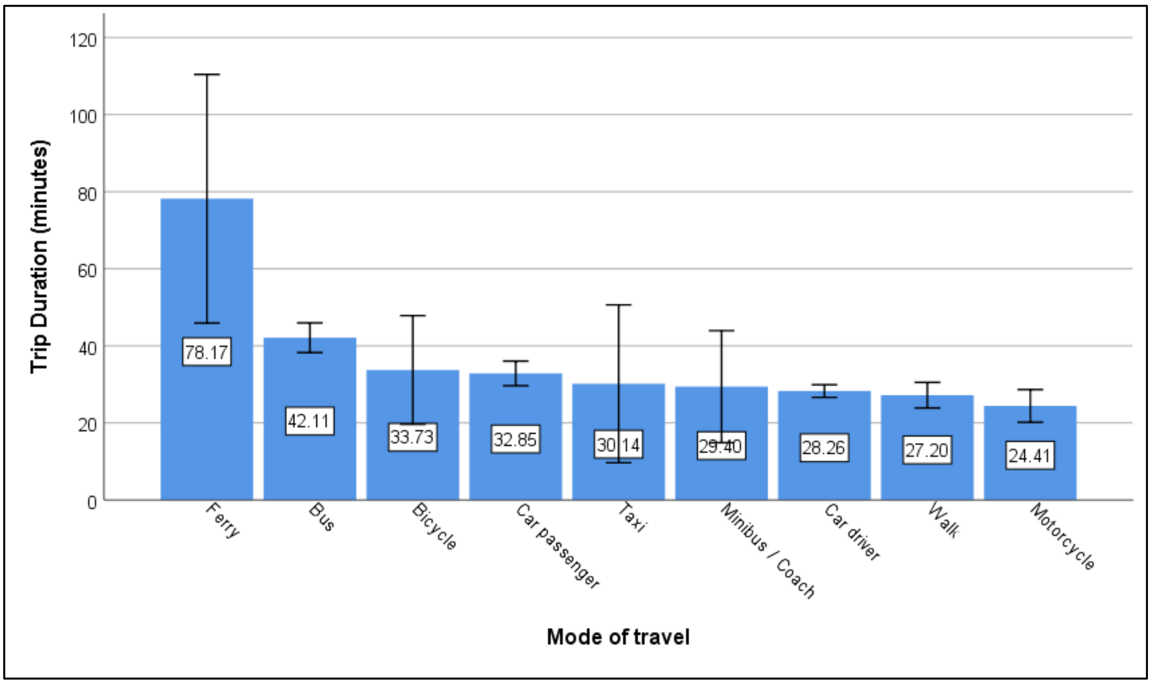



**Figure 5.5: Trip duration**

The mean trip duration was further analysed based on the activity at destination. The results of these descriptive statistics are shown in Figure 5.6. The average trip spans from 48 minutes to 22 minutes. Most of the trips have an average duration of around 30 minutes. Trips made for the purpose of business, medical visits and leisure activities were amongst those having the highest mean trip duration.

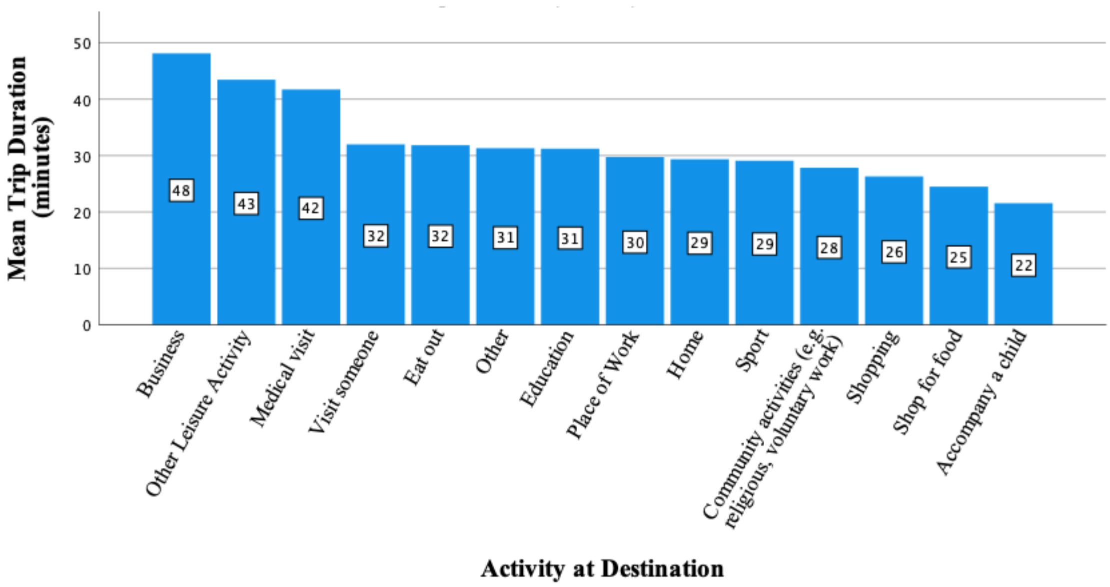



**Figure 5.6: Mean trip duration by activity at destination**

### 5.2.7 Distribution of Trip Time

The distribution of the daily trips over the day was also analysed. For the purpose of this exercise, the data was split into two sets; one of the sets including the data for weekday trips while another set describing trips made during the weekend. For the two sets the data was aggregated to show the distribution of trips during different hours of the day. The time series of weekday and weekend trips are presented in Figure 5.7.

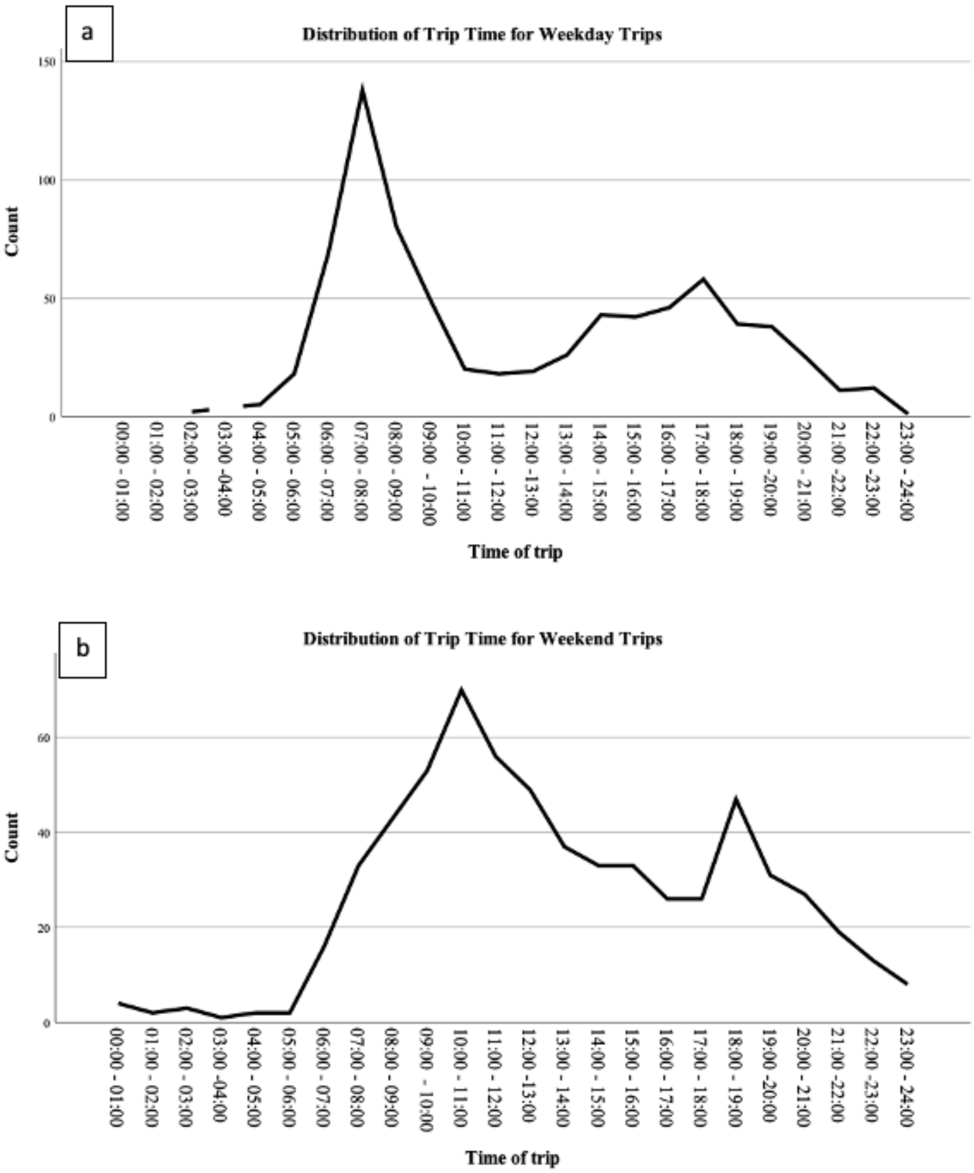



**Figure 5.7: Daily distribution of trip time a) during weekdays b) during weekends**

The distribution of trip times has two peaks, one in the morning and one in the evening. The largest proportion of trips are made during these peak hours. The double peak distribution is characteristic of commuting patterns which are usually found in transport studies. The morning peak represents the rush hour, where individuals are commuting to work while the evening peak reflects the time when individuals finish work and head home or to other activities.

The graph displaying the weekday trips shows a significant difference between the morning and evening peaks. The morning peak which occurs at around 7:00 to 8:00 am is quite pronounced, while the evening peak is flatter and broader spanning from 16:00 to 19:00. The difference between the morning and afternoon is less pronounced for weekdays. The morning peak occurs later during the day when compared to the distribution of trips during the week and is observed around 10:00 to 11:00am. During weekends, the afternoon peak is sharp with a high number of trips happening between 18:00 to 19:00. From Figure 5.7 it can be also noted that a larger number of trips were reported for weekdays when compared to weekends.

### 5.2.8 Time dependence of social practices

Social practices are ordered across space and time (Giddens, 1986). The socio-temporal organisation of daily practices shape the timing of social practices and how these take place during daily lives (Schatzki, 2010). The complexing of different social practices and sequencing of different practices create the rhythms of daily life (Southerton, 2003). Understanding the time-dependence of practices and their distribution can provide a deeper understanding of the demand for mobility and how interventions in different areas of the social life can help a shift towards more sustainable mobility.

This section will provide an analysis of the distribution of social practices over time. Figure 5.9 illustrates the distribution of different social practices during both weekdays and weekends. The figure shows that significant differences can be observed for the distribution of social practices during weekdays and weekends. Traveling for work is one of the most dominant practices during weekdays. Travel for the purpose of reaching the place of work is the most common type of trip made by individuals during weekdays and this trip type occurs mostly during the morning. Contrastingly, trips made for the purpose of returning home are made later during the day. This type of trip is observed to occur over a wider time range than that observed for the commute for work purposes. Figure 5.9 also shows how travelling for sites of education is also an important practice during the morning hours (06:00-11:00). Participants in the survey also reported travelling to accompany children mostly during the mornings and in the afternoon (13:00-17:00). Trips made for the purpose of shopping for food, visiting someone and engaging in sport activities tend to happen later in the day (16:00-20:00).

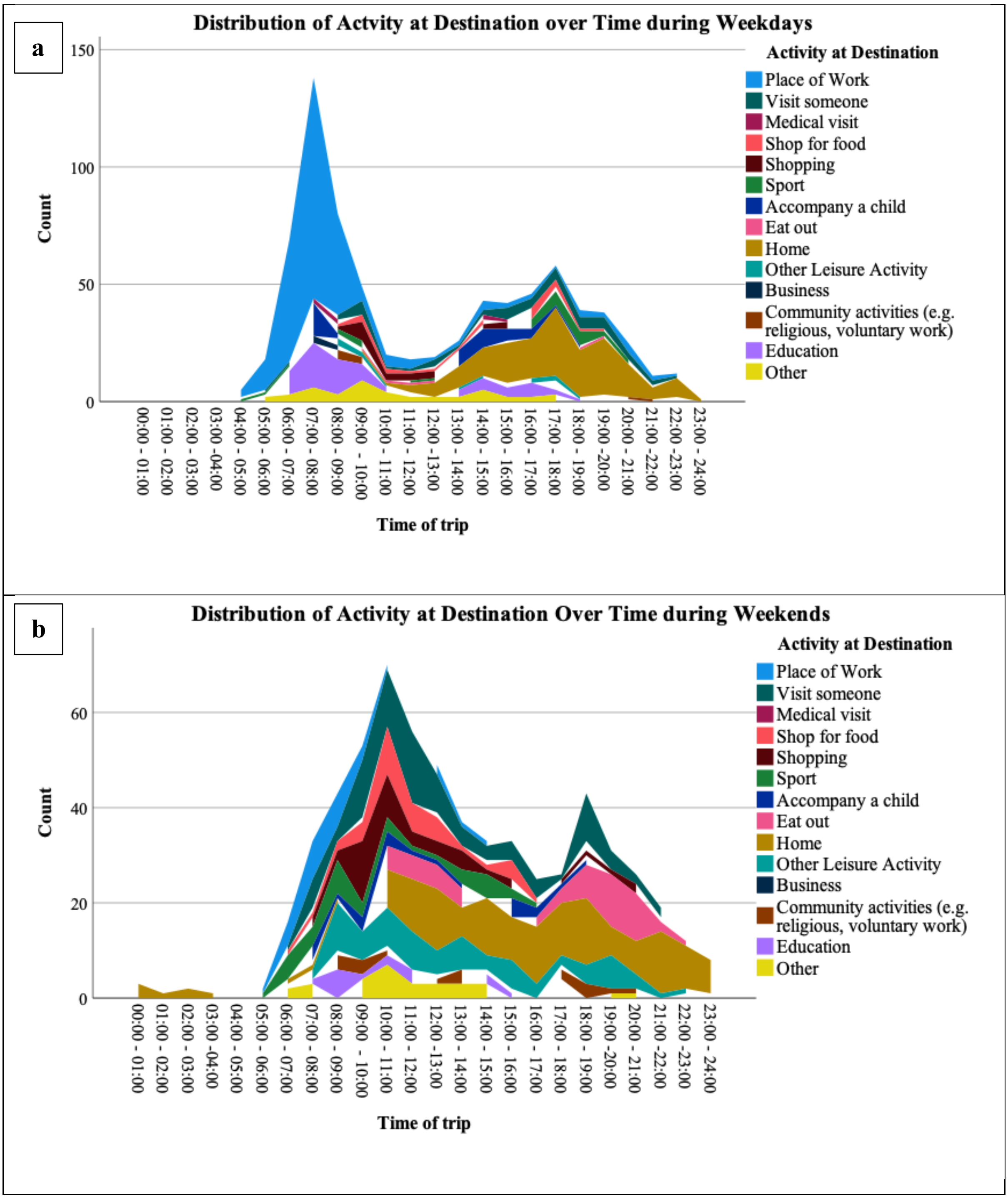



**Figure 5.9: Distribution of activities at destination over time during a) weekdays, b) weekends**

Different patterns of trip distribution are observed for weekends. The data shows that the trip purposes made during the weekend are very different from those during the week. The most prominent trip purposes during the first half of the day during weekends (6:00-13:00) are include trips made for visiting someone, shopping, and shopping for food, eating out and participating in leisure activities. Later during the day, most of the trips are made for the purpose of eating out, visiting someone and other leisure activities.

### 5.2.9 Conclusion

This section has presented the findings from the survey data. The analysis and results demonstrated a high dependence on the car as the preferred mode of travel amongst the population. Other modes such as using the bus, cycling and walking are less popular.

The data also showed how mobility practices are a derived demand and individuals chose to travel to reach destinations where they can actively participate in their activities. The analysis therefore shows a number of other social practices which complex with mobility or rely on mobility for their performance. Clearly, traveling for work is an important social practice. Other social practices for which individuals travel to include education, shopping, shopping for food, leisure activities and engagement in sport activities. The data shows that the modal choice is influenced by the type of activity at destination. For example, the data showed that most trips made for the purpose of accompanying a child were made by car. Similarly, activities where the reliance on the car was high included traveling for work and engaging in sport activities.

## 5.3 Mobility as a social practice

This section describes the results of the qualitative study carried out to explore in more-depth the current mobility practices. The analysis was based on the data collected from a set of twenty (20) interviews carried out with a range of participants which represent different lifestyles and experiences on mobility. The aim of this qualitative analysis was two-fold. First, the data will serve to uncover the constituent elements that make up the current mobility practices. Second, the results of the interviews will demonstrate how the current mobility practices are shaped by the daily lives of the participants and other social practices.

### 5.3.1. The interviewees

The main details of the participants are described in Table 5.9. The sample consisted of ten (10) male and ten (10) female participants aged between 18 and 65. The participants resided in different areas of Malta covering all the regions in the islands. The employment status of the participants is varied and includes students, retired individuals, managers, academics/educators and individuals with administrative roles.

The participants were also purposively selected to include a range of mobility practices. This selection process resulted in a sampled population with participants showing preference towards different modes of travel. Nine (9) of the participants stated that their preferred mode of travel was the car, two (2) make use of a bicycle to travel, another one prefers to travel on foot and four (4) listed the bus as their preferred mode of travel. The rest of the participants make use of a combination of different modes to travel. The sampled set of interviewees was also chosen to represent a varied range of lifestyles with participants ranging from those having family responsibilities including children, young adults, self-employed individuals and others who are not in employment.

**Table 5.9: Characteristics of the participants**

| Interview | Gender | Age | Preferred mode | Employment Status / Type | Region of residency | Other Comments |
|---|---|---|---|---|---|---|
| 1 | Male | 22 | Bus/ Car | Student | Western | Full-time student, participates in other activities related to music after college hours |
| 2 | Male | 29 | Car | Management | Southern Harbour | In full-time employment, enjoys outdoor activities in his free time |
| 3 | Male | 24 | Bus/Walk | Professional | Northern Harbour | In full-time employment, travels primarily by bus. Outside work he visits friends and participates in other social activities |
| 4 | Female | 40 | Car | Management | Northern | Manages a school for performing arts. In her free time she likes to socialise and mainly uses the car to get around |
| 5 | Male | 38 | Bike | Teacher / Business man | Northern Harbour | A business owner and a teacher who uses the bike to travel to his activities. He makes use of the car when he takes his family for outdoor activities |
| 6 | Female | 40 | Bus | Self-employed | Northern Harbour | A parent who works from home, she uses the bus as main mode of travel and walks to the site of her activities |
| 7 | Male | 40 | Bike | Administrative | Southern Harbour | Is in full-time employment and participates in sport during his free time. He does not own a car and makes most of his trips using his bicycle |
| 8 | Female | 58 | Car | Professional | Northern Harbour | Works as a full-time learning support assistant. Makes use of the car to go to work but chooses to run her errands on foot at shops which are close to her home |
| 9 | Female | 31 | Car | Professional | Northern | Full-time employee and mother to two children. She says that owing a car is necessary to attend to the needs of her children |
| 10 | Female | 34 | Car | Professional | Northern | Employed full-time and active with voluntary organisations in her free time. Uses the car as the main mode of transport |
| 11 | Female | 34 | Bus | Lecturer | Northern | Uses the bus to travel, however states that this limits her mobility |
| 12 | Male | 42 | Bus / Taxi | Administrative / Clerical | Northern | Does not own a car and uses the bus to travel. He finds this mode of travel limiting in terms of accessibility and efficiency |

| | | | | | | |
|---|---|---|---|---|---|---|
| 13 | Male | 65 | Car | Retired | Gozo | Retired teacher who prefers the car to travel around to move between his daily activities |
| 14 | Female | 32 | Car | Professional | Gozo | A young female who is in full-time employment. She makes us of the car to meet her mobility needs |
| 15 | Female | 58 | Walk | Administrative | South-Eastern | An older female, still in employment. She does not own a car and makes use of the bus or walks to the sites of her activities |
| 16 | Male | 36 | Car | Professional | South-Eastern | Uses the car to travel to and from work and to meet the mobility needs of his family |
| 17 | Female | 19 | Bus | Student | Western | A teenage female who does not own a car and travels using the bus |
| 18 | Male | 18 | Bus | Student | Western | This young male travels using the bus as the main form of transport. He says that having a car would facilitate his travels |
| 19 | Female | 45 | Walk / Car | Administrative | Western | Her place of work is in the same locality where she lives allowing her to commute on foot |
| 20 | Male | 55 | Electric Car | Senior Management | Southern Harbour | His environmental consciousness pushed him to opt for an electric car to travel to his activities |

*Source: adapted from Camilleri et al. (2022)*

### 5.3.2 Constituent elements of mobility practices

During the interviews, the participants spoke about different forms of mobility practices. Their discourse included their experiences on both their preferred mode of travel, but also on other modes of mobility they do not usually engage in. The data analysis uncovered the current mobility practices which are available for the participants to enable them to move between activity sites.

The data collected from the semi-structured interviews were analysed qualitatively based on the Theory of Social Practice as underlying framework and as described in the methodology (Section 4.5.4). From the perspective of practice theory, social practices including mobility are composed of a complex set of interconnected elements. These elements which include materials, competencies and meanings (Shove et al., 2012) are crucial for the performance of the social practices. The analysis of the semi-structured interviews in this study served to provide insights on the constituent elements of the current mobility practices in Malta. An understanding of the interconnections between the elements of mobility practices can indicate how some practices endure while others do not easily recruit individuals.

Examining the way material elements of mobility interact with meanings attributed to the practice, and the competencies involved in the performance of the practice can reveal how some mobility practices such as driving the car predominate over other forms of low-carbon travel. Such an insight may start to highlight which elements of mobility practices can be targeted in the transition from car-based travel to more sustainable forms of mobility.

Table 5.10 lists the constituent elements of the current mobility practices which became evident from the qualitative analysis. At first glance, the data in Table 5.10 indicates how different mobility practices are made up of different materials, a set of unique competencies are needed for their performance, and different meanings are given to different forms of travel. While all elements of these practices are crucial for mobility practices to be performed and endured, some elements may have greater influence on the recruitment of practitioners than other elements. This section will focus on the elements of mobility practices as experienced by the participants and how their interconnectedness is important for practices to endure.

**Table 5.10: Elements of mobility practices**

| Materials | Competencies | Meanings | |
|---|---|---|---|
| ***Car*** | | | |
| - Storage capacity<br>- Lack of road enforcement<br>- Parking spaces - Congestion | - Driving license<br>- Road rules<br>- Navigation<br>- Reading traffic updates<br>- Reading weather forecasts | - Ambition<br>- Clean<br>- Comfort<br>- Necessity<br>- Efficient<br>- Pleasant<br>- Convenient<br>- Independence<br>- Personal space | - Isolation<br>- Stress<br>- Expensive<br>- Negative environmental impact |
| ***Bus*** | | | |
| - Roads<br>- Bus<br>- Bus stops<br>- Limited storage capacity<br>- Limited accessibility<br>- Low frequency | - Reading route maps<br>- Use of route planning applications | - Good use of time<br>- Less stress<br>- Meeting other people<br>- Environmentally friendly<br>- Time to appreciate surroundings | - Unclean<br>- Lack of personal space<br>- Inefficient<br>- Unreliable<br>- Lack of status<br>- Limiting<br>- Uncomfortable |
| ***Bicycle*** | | | |
| - Bicycle<br>- Electric bicycle<br>- Waterproof clothing<br>- Carry small objects<br>- Short distances<br>- Lack of proper infrastructure<br>- Lack of shower facilities | -Cycling knowledge<br>- Ability to cycle uphill<br>- Navigation | - Extension of one's legs<br>- Low cost<br>- Fast<br>- Freedom<br>- Healthy way of travelling | - Unsafe<br>- Relaxing<br>- Social aspect<br>- No parking problems |
| ***Walking*** | | | |
| - Short distances<br>- Rainproof kit<br>- Good walking shoes<br>- Lack of proper infrastructure | - Walking fast<br>- Familiarity with walking<br>- Calculating distances | - Social aspect<br>- Benefit to health<br>- Relaxing | - Unsafe<br>- Breathing polluted air |
| ***Ferry*** | | | |
| - Shelter on ferry<br>- Boats<br>- Bicycle racks | - Knowing ferry routes | - Low cost<br>- Pleasant | - Service limited to few locations |

*Source: adapted from Camilleri et al. (2022)*

#### *5.3.2.1 The car, functionality and convenience*

A number of elements associated with the car became evident from the thematic analysis of the interview data. These elements are illustrated graphically in Figure 5.10. The figure shows the results of the qualitative analysis in a quantitative form. To do so, the themes which emerged from the qualitative analysis of the interview data were clustered together and the frequency with which each of the themes appeared in the interviews was calculated. These results were presented in the schematic shown in Figure 5.10, where the size of the circles represent the number of times each theme was mentioned in the interviews.

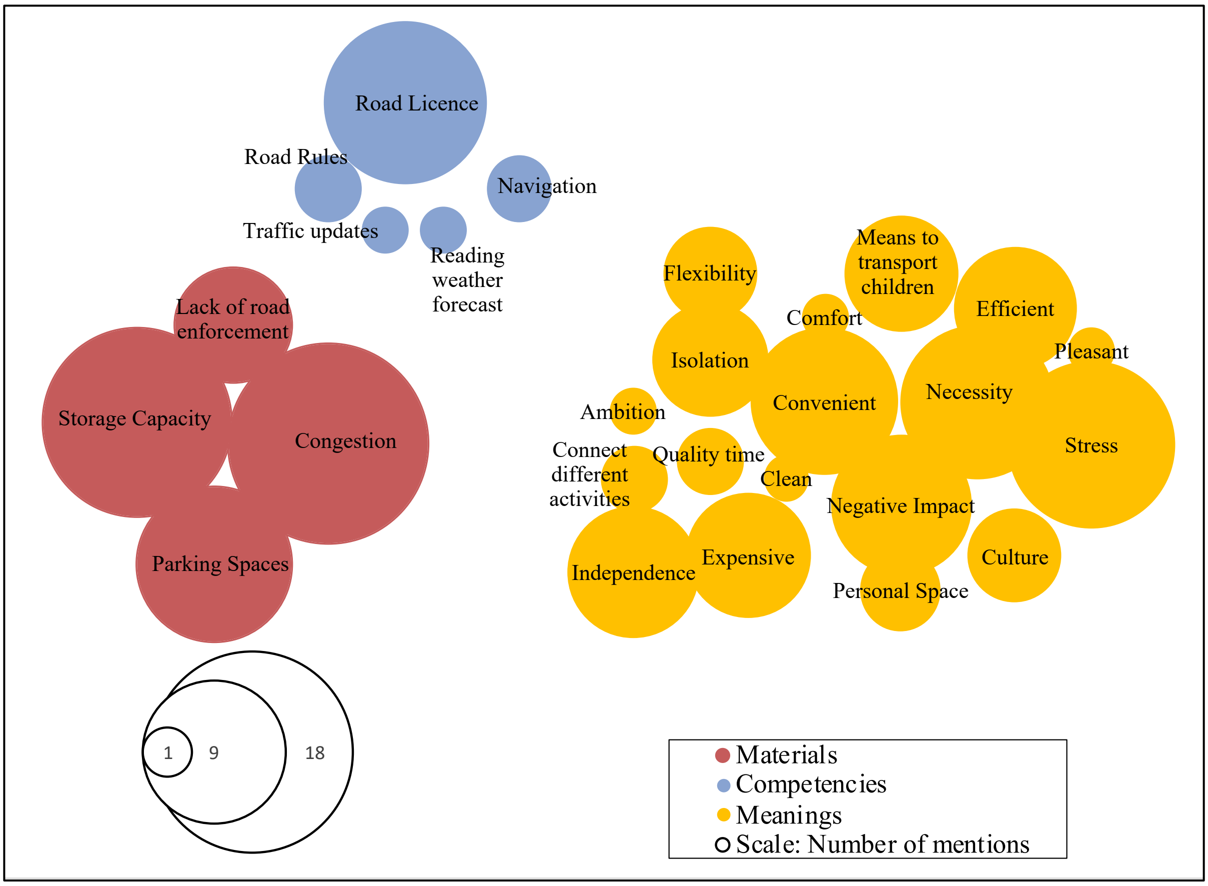



**Figure 5.10: Elements of car driving**

Participants spoke about the practice of driving the car, the materials that enable the practice, the competencies they require and the meanings that inspire them towards the use of this mode of travel. Most of the participants expressed how one of the most important material element of car driving is the car itself which offers the capacity to store and transport objects. Throughout the interviews, participants explained their need to be able to carry objects, which need can be met by the carrying capacity of the car. The following quotations from the interviews illustrate this: (Numbers in brackets refer to the interviewee number in Table 5.9).

(2) *If I am carrying certain equipment, certain gear, the luggage of the car itself is a huge advantage of the car which other modes of transport do not have.*

(3) *I can buy things from a supermarket because if you don't have a car you can't carry heavy things for more than a few minutes.*

The interviewees explain how this element of car driving provides an advantage over other forms of mobility such as cycling or using the bus which are limited in their capacity to allow for transporting objects. This is evidence from the data collected during the interviews.

(8) *It's difficult to go shopping by bus*, *I mean if you have a lot of bags, it's difficult to carry everything.*

(7) *I have a bag on the front of the bicycle, but obviously, you're limited, you cannot do a whole shopping with your bicycle.*

These findings are in line with the current literature on the motives for car use, where it is widely acknowledged that the practical aspects of car use are positively valued (Steg, 2005; Steg et al., 2005). One of the strong motivations to use the car is the instrumental-function of the car which provides flexibility, fast travel times and a means to carry one's goods (Bergstad et al., 2011; Lois et al., 2009).

When speaking about car driving, participants in the study attributed a significant number of positive meanings to this mode of travel. From the data, it became evident that car driving is often associated with a convenient way of traveling between different daily activities. Another important meaning attributed to the car is the independence that this type of mobility practice provides.

(13) *Let's be honest about it. The car is absolutely convenience*

(19) *To be totally independent you need your car*

In addition, car driving is also given other positive meanings such as being an efficient mode to travel, it offers flexibility, it is pleasant and allows individuals to connect different activities which are also part of their daily lives. Car driving is also viewed as necessary, and it provides its users with a good level of personal space. These positive meanings of car driving are similar to those in literature, (Anable et al., 2005; Beirão et al., 2007; Hiscock et al., 2002; Mann et al., 2006) which show how mode choice is not only dependent on instrumental functionality of the means of travel but is also affected by non-rational factors which include meanings which individuals associate with different modes.

The interviewees also explained that while car driving is convenient and offers flexibility for moving from A to B, current material elements associated with car driving such as the lack of parking spaces they encounter, the high levels of congestion they experience together with lack of road enforcement make this form of travel stressful (Figure 5.10). The stress caused by car driving is one of the few negative meanings associated with this mode by our participants. Semi-structured interview data has also shown that participants also associate car travel with negative environmental impacts. These results are similar to other data on the meanings attribute to car use (Hagman, 2003). Despite this perceived stress caused by this mode of travel and negative impacts, car travel is still the most preferred mode of travel. This may suggest that these negative meanings are outweighed by other elements of car driving when compared to other modes of travel.

The driving license is the most important of competencies for car driving. However, this is not the only skill required to engage in car driving as a mobility practice. Other competencies including following road rules, navigating to destination, and reading information on traffic and weather conditions are also essential. These results are very similar to those obtained in studies which analyse mobility through the Theory of Social Practices perspective (Beirão et al., 2007; Cass et al., 2016). These competencies are important for car driving practices, thus allowing individuals to modify their route to achieve the most efficient travel times.

#### *5.3.2.2 The bus, longer travel times, less stressful*

The set of elements that describe bus use are very different to those for car driving mobility practices, as can be observed in Figure 5.11. The material elements of bus use in Malta uncovered through the qualitative study indicate that the bus network that provides for public transport is limited. From the experience of the interviewees, the public transport system provides limited accessibility to some areas of the islands as exemplified by the following set of quotes:

(11) *there are some places which are simply not accessible by bus, like some spots in the countryside.*

(2) *I'm a bit of an outdoor person. There are certain places which are not serviced by public transport easily, so I need the car to get to these places.*

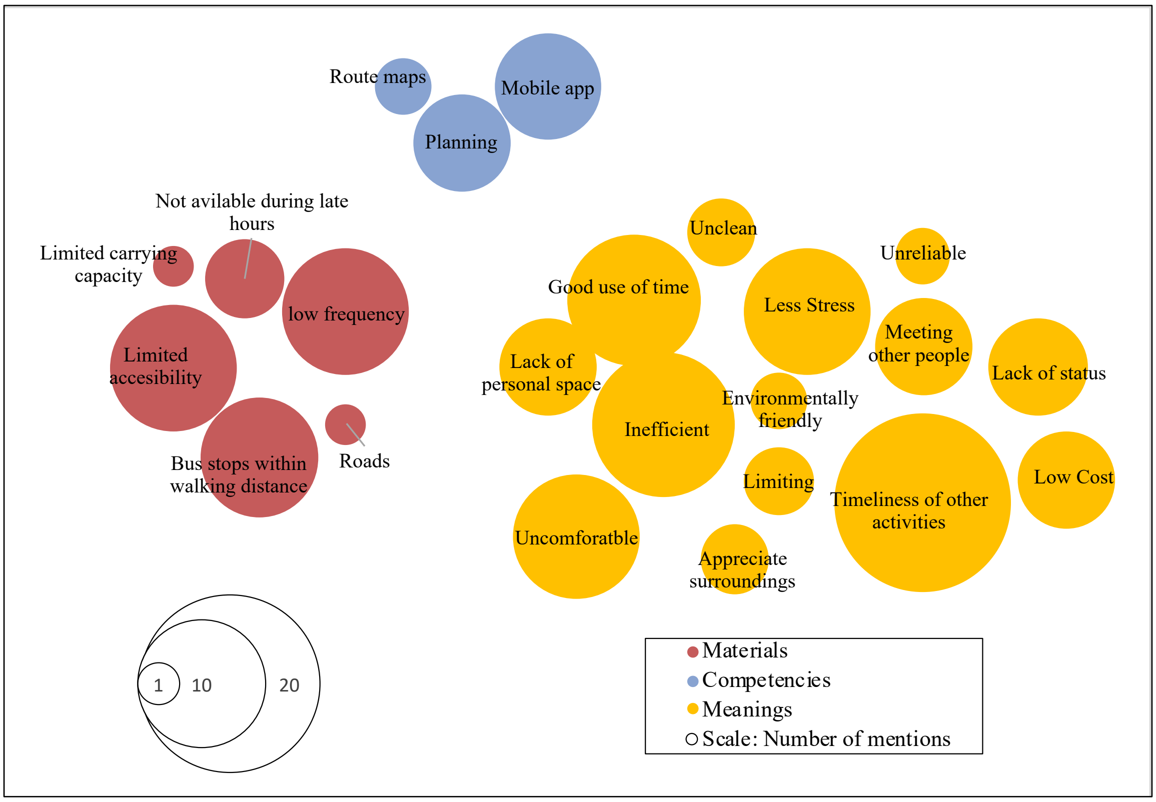



**Figure 5.11: Elements of bus use**

From the perspective of the interviewees, the current public transport system does not provide a service with the necessary frequency that allows the users to reach their destination in an efficient and timely manner. Through the interviews, the participants also mentioned how the bus service is not available during the late hours of the day.

(17) *Sometimes I have to wait for around 30 minutes to catch the bus after school. Other times, the bus does not keep to the schedule, and I lose a lot of time waiting in vain.*

These material elements of the public transport system in Malta influence the meanings of bus use as a mobility practice. The qualitative analysis revealed that travelling by the bus is perceived to be limiting for individuals since they cannot reach some destinations easily. In addition, their travel times is dependent on the frequency of the buses and the set time schedule. The low frequency, unreliability and long waiting times also means that sometimes the bus does not meet the individuals need to be on time for their activities.

Other meanings attributed to the bus, which make this mode of travel less attractive in contrast to the car include the lack of personal space, the perceived lack of journey comfort, and the level of cleanliness, which the participants perceive as out of their control, yet not to their liking. Long journey times also tend to discourage bus use over other forms of transport. These negative meanings related to the bus are similar to those found in other ransport studies (Beirão et al., 2007; Metz, 2008; Stradling et al., 2007). These findings suggest that if the bus is to compete with the car, the bus service must offer the quality desired by the users. Travel time, comfort and reliability are key factors that determine choice of travel mode.

Despite the results showing significant negative meanings related to bus use, participants also attribute positive meanings towards this form of travel. The low-cost associated with this mode is one advantage for travelling with the bus

(2) *The bus is free, because I am a student. I won't deny that is a factor which influences how I travel.*

(12) *My employer pays for the use of the bus. So, transport would be cost free if I have to use the bus. But I don't make use of the bus because the journey by bus takes too much time.*

Through their interviews, participants narrate that travelling by bus is less stressful than using the car. When travelling by bus, individuals do not need to put in energy to navigate the car, focus on traffic or find parking at their destination. For the participants, using the bus also means that the journey time can be transformed into productive time where they can listen to music, read a book, or get some work done. This use of journey time is not possible with car travel where the driver needs to be focused on driving during the whole time.

(11) *When I think of people driving cars in traffic, I'd say why on earth would I want to do to that? I honestly think that being stuck in traffic adds the stress levels. With the bus it's less stressful. Even in heavy traffic, I'm just sitting down or standing up reading a book, listening to music. I'm not looking around making sure no one crashes into my car.*

The results of this study show that the bus means an environmentally friendly way of travel and a space where one can meet other people making the journey less solitary than other modes of transport. The qualitative data analysis is also useful to show how using the bus requires a set of unique competencies which are different from those needed for other mobility practices. For example, traveling from point A to point B with the bus in Malta requires the ability to read information about the bus route and using mobile phone applications designed to provide users with information about the timing of the bus. In addition, making trips using the bus and arriving at the destination on time also involves the capability to be able to plan the trip using the bus timetable.

(17) *Google maps gives me the route and the time when the bus will arrive. I also have information of the best route and it gives you the list of all the buses that you can use to reach your destination.*

Such findings show that while material elements including the provision of a high frequency service are important to allow users timely arrival at their destination, knowledge on how to find the best route and plan the journey are also key for the transition from car to bus mode of travel. These insights and their implications for policy will be discussed further in Chapter 9.

#### *5.3.2.3 Walking and Cycling, relaxing but still unsafe*

Participants also discussed various aspects of walking and cycling during the interviews. The results presented in this section reflect the views of both those who engage in these mobility practices as their primary mode of travel and those who prefer other modes of travel to their destination. The elements of walking and cycling are shown in Figure 5.12 and 5.13 respectively.

The small size of the Maltese islands and the relative short distances between sites of activities is perceived to be an advantage for active modes of travel. Short distances mean that trip times are kept low even if one decides to walk or cycle as we can observe from the quotes which follow:

(5) *We have very short distances in Malta. I think the average commute is around five kilometres, which is very short. Considering an average speed of 20 kilometres that's 15 minutes away.*

(7) *In Malta the distances are very short. I think the perception is that journeys are long with the bicycle. But I think when you actually start cycling, you realize that there is no such thing as long ways here in Malta.*

In their interviews, the interviewees also discuss how the lack of proper infrastructure including dedicated cycling lanes and wide pavements are often a barrier for cycling and walking. The unavailability of a good infrastructure contributes to the meaning of unsafe which has been attributed to active forms of travel. This is in agreement with other studies on active forms of travel which have found provision of proper infrastructure achieves higher levels of cycling and walking (Moudon et al., 2005; Pucher et al., 2008b).

(5) *People don't feel safe when cycling. I speak a lot with colleagues and young people and they say that they are not at ease when using a bicycle.*

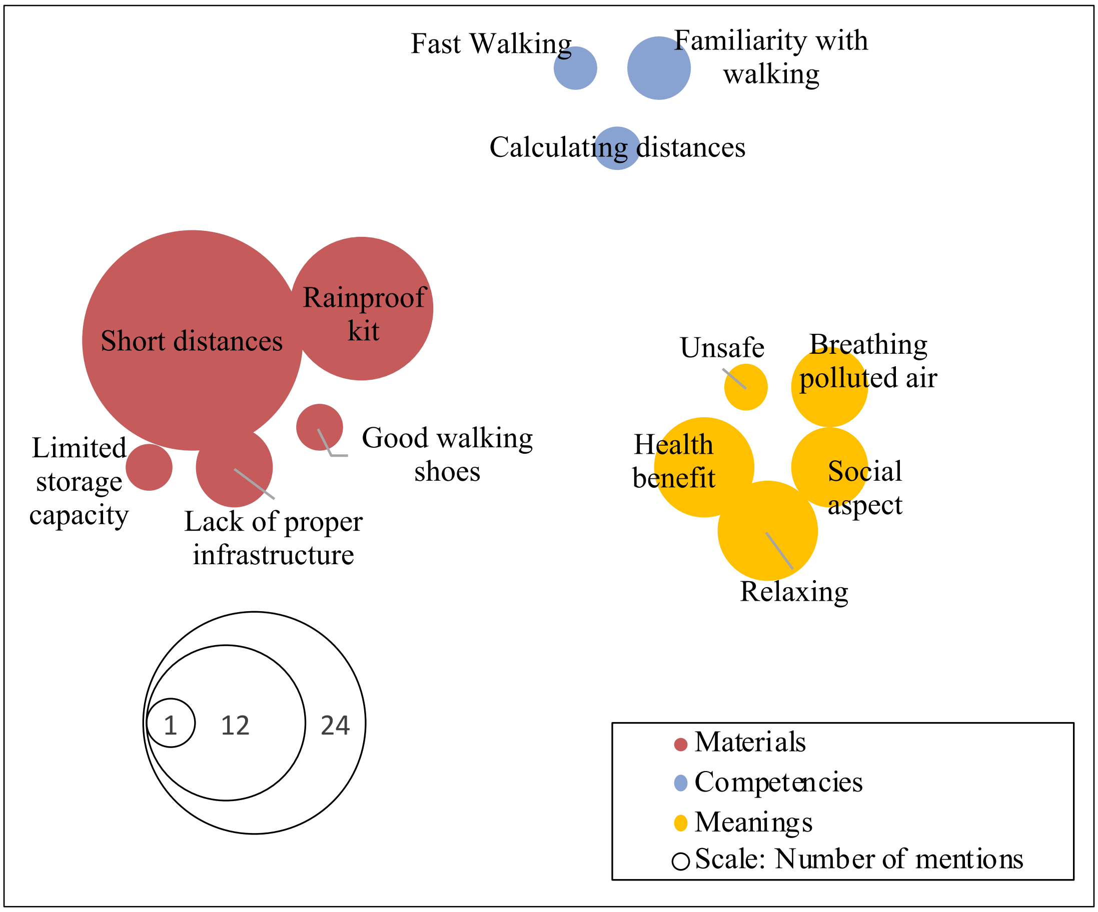



**Figure 5.12: Elements of walking as mobility practice**

Despite the feeling of unsafety, a number of positive meanings are attributed to walking and cycling. Active forms of mobility, in contrast to other types of travel, enable the individuals to relax, they provide a sense of freedom away from traffic congestion, and are perceived as beneficial for health.

(3) *I just walk home after a long day of work. It's just, it's just really good to relieve stress.*

(5) *The sense of freedom, the sense of not being affected by traffic.*

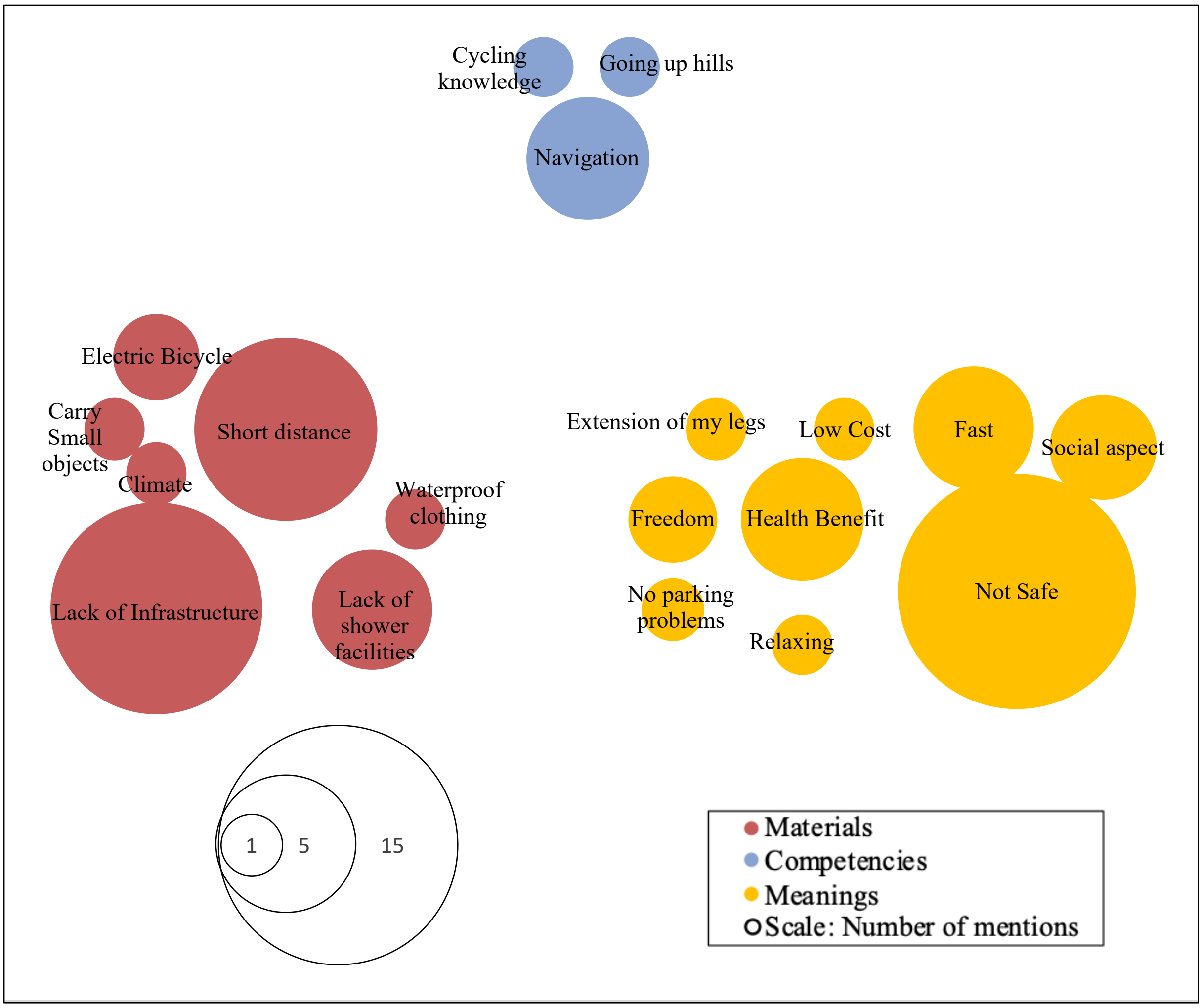



**Figure 5.13: Elements of cycling**

The qualitative analysis of the interview data was also important to reveal that for individuals to use walking and cycling to travel from A to B, they require a unique set of skills that enable them to engage in these practices. For example, non-cycling participants point out how the major barrier to the uptake of cycling is the lack of cycling skills. The data from the study showed that most of the participants seemed to lack competencies required for cycling with some individuals stating that they wish to start cycling but feel they lack the knowledge or are afraid of using this mode of travel.

(17) *I don't really know how to ride a bicycle and the roads are not adequate.*

Another competence that was also evident from the discussions is a good level of fitness which would allow the practitioners to travel using a bicycle. The results are comparable to similar studies investigating cycling, where competencies, including the level of fitness required for individuals to take up cycling, seem to be lacking (Spotswood et al., 2015).

One advantage which facilitates bicycle use in Malta, and which became evident from the interview data, is the short distance between sites of activities. The interviewees recount how the small size of the islands means that travel can be easily covered by a bicycle. On the other hand, the steep topography of the islands and the high temperatures experienced during summers are considered as barriers to cycling.

(13) *I can use the bike although, there are some steep hills and if it's summer then you would get all sweaty and all that. So, again, it's not very convenient because of that.*

These results are concordant with other studies that have examined factors influencing bicycle use. Research focused on Malta as a case study have shown how the islands exbibit characteristics such as hot summers, high humidity and hilliness which act as barriers to cycling (Maas et al., 2021).

When it comes to walking, the interviewees emphasised three important competencies. First, is the importance of being familiar with walking as an alternative mode of travel, the ability to walk with a fast pace, and having the skill to calculate distances and travel time for different destinations.

(6) *I walk a lot. For some it's actually considered a lot if you walk 20 minutes, for me it's quite normal.*

These findings again demonstrate how material elements are important for individuals to be able to engage in practices. However, without the necessarily competencies and positive meanings, the availability of material elements would not be enough for practices to endure.

#### *5.3.2.4 Travelling with the ferry*

Travelling with the ferry presents a unique set of elements which are very different to other forms of mobility practices. This form of mobility is particularly important for this study for the reason that current literature on social practices does not analyse this mode of travel as a social practice. In the geographical context of this case study, travelling with the ferry constitutes an important aspect of mobility.

Sea transport in Malta covers two main areas. The most commonly used ferry service is that which links the two main islands, Malta and Gozo. The ferry operates between the port of Cirkewwa (Malta), which lies in the North part of the island and the port of Mgarr (Gozo) shown in Figure 5.14a. Another important sea transport service is that which allows for travel within the Grand Harbour. This ferry service connects Valletta, the capital city to Sliema on one side and the three Cities to the other side (Figure 5.14b). The ferry service started operating again in 2012 (Transport Malta, 2016a) following many years of inactivity. The ferry service in the Harbour supports the public transport system and has the potential to reduce congestion on the road network.

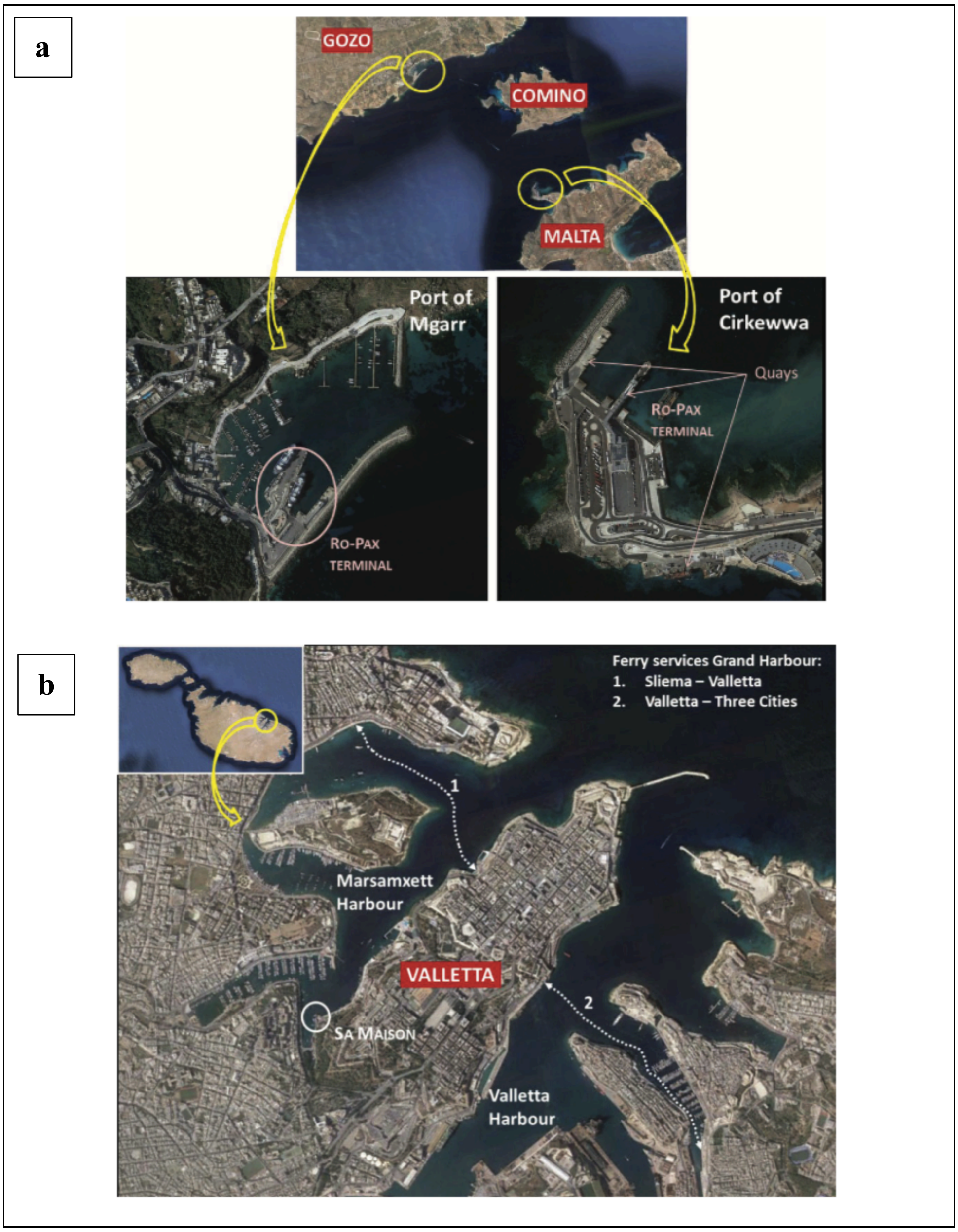



**Figure 5.14: a) Mgarr and Cirkewwa ports, b) Ferry service in the Grand Harbour**
*Source: Transport Malta (2016)*

The meanings that our participants associate with ferry services were often positive meanings (Figure 5.14). In their discussion, they described how using the ferry was a pleasant experience. The cost of this type of service is also perceived as low thus not a barrier for using this mode of transport. The availability of bicycle racks on the ferries operating in the Harbour allows for easy multi-modal travel in the area. One disadvantage which became evident from the data is that the service is only limited to a small area. The participants note how they would be willing to use the service if this was also available in other areas.

One competence that is essential for this mode of travel is knowledge about the routes and ferry time-tables. This competence is important especially when travelling with the ferry as part of a multi-modal journey.

(14) *I always look at the time-table before my trip with the ferry. When I don't check the schedule I always regret it as I often see ferry leaving when I get to the terminal.*

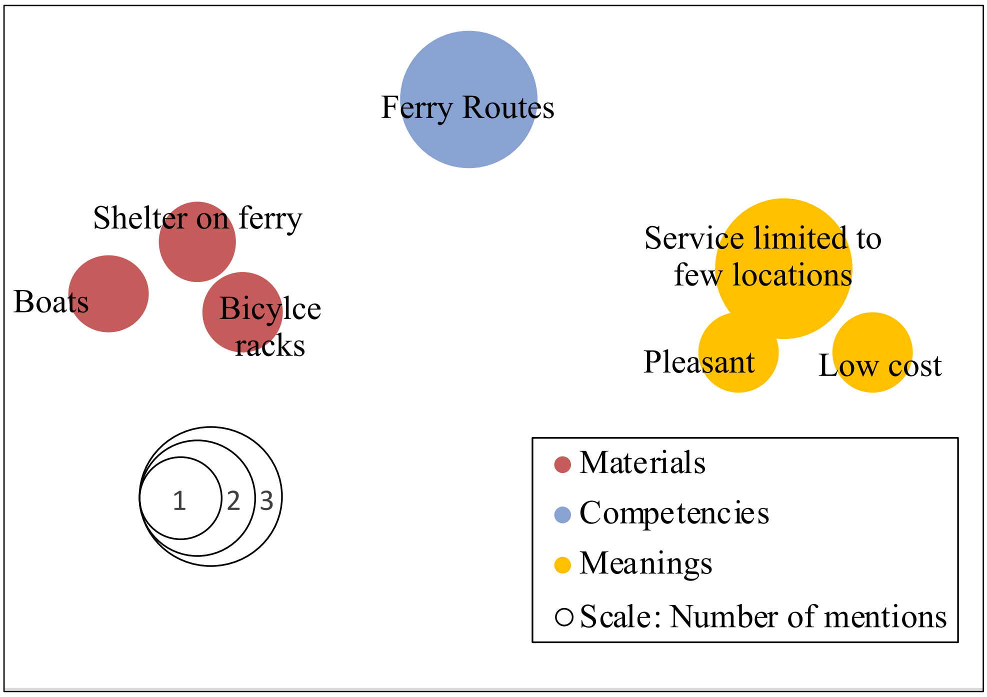


**Figure 5.15: Elements of using the ferry as mobility practice**

### 5.3.3 Mobility and other social practices

The interviews collected as part of this research are also a useful source for identifying how different social practices interact with mobility practices, shaping the recruitment of individuals to different types of travel. This section presents the data from the semi-structured interviews where the participants share how their day-to-day lives, and their lifestyles influence their transport mode choices. One common theme that emerged across the data is that the recruitment to some mobility practices depends on the fixed starting or finishing times of other social practices. This is most evident when the interviewees describe the activities involving work and education.

(1) *If I had to take the 6:15 bus to university, I would get here by seven, which is an hour early to when I need to, but then catching the 7:15 bus would make me arrive at 8:30, which is too late for lectures.*

Other participants describe how their job requires them to be mobile during the day and hence pushes them towards using the car for their mode of travel.

(11) *I used to work with a newspaper and being a non-driving journalist is very tough. It limits your work.*

One important trend that emerges from the data collected is the importance of the spatial distribution of the social practices that individuals engage in during their daily routines. For example, the participants highlight how this spatiality, such as living in the central urban area, affects their use of low-carbon modes of travel. The data shows that individuals are able to adopt low-carbon types of mobility practices when the distance between different sites of practice are short.

(12) *I live in the central part of the town. So, when I pop out the door I find everything around so it makes it easier for me. Other people, I think they have to go by their car.*

Participants adopting low-carbon forms of mobility engage in social practices which do not necessitate travelling over long distances. One such example can be seen when participants make decisions on changes to jobs or school. This applies not only to the commute between home and work but also for activities which occur during the daily routines of the participants such as for example, engaging in sports activities.

(11) *For example, around six years ago I went through a career change and there were certain jobs I didn't consider simply because I do not drive.*

Travelling by bus takes a longer time than getting to the site of activities by car and mobility by bus means that an individual can fit less activities during his/her daily routine.

(12) *It takes longer to do certain things after work when someone might have time to run, three errands, I know I'll only have time to run one and a half errands.*

These representative quotes show the effect of the pressures of coordinating different practices, including work, education, and other leisure activities, on mobility. Data collected during the study also demonstrated the effect of other social practices on mobility, one of the most impactful being parenting. As the participants of the semi-structured interviews narrated, parenting brings with it the needs to travel between different sites of practices. For example, working parents have to drop the children at school before going to their place of work, and the car is often seen as the most viable means of meeting these needs.

(11) *When I think of my close friends have children, I don't think that they will be able to cope using the bus. My mother got a license because she couldn't continue taking us around with the bus, 25 years ago.*

The data gathered through the interviews has shown that looking after children has important effects on travel. Other studies (He, 2013; Pooley et al., 2011) have commented similarly on the parents' role and the need to coordinate not only their activities, such as work, but also tend to the travelling needs of their children. This increased need to move between different sites drives individuals to adopt mobility practices which are most efficient in terms of time, and often lean towards car use.

### 5.3.4 Final Comments

The results of the qualitative analysis clearly show how the individual mobility practices are composed of a unique set of elements (materials, competencies and meanings). The availability or lack-of these elements determines which of these mobility practices prevail while others fail to recruit practitioners. The data was also important to show how the influence of other social practices on mobility. Like previous findings (Iyanna et al., 2019; Mattioli et al., 2017; F Meinherz et al., 2020; Shove et al., 2015; Spurling et al., 2014), the fixed timings for work and school, parental responsibilities, shopping and other activities shape the mode choice of individuals.

## 5.4 Conclusion

This chapter has focused on the results of the first phase of the research, which answered the first research question namely; *what are the current mobility practices in Malta?* The results of this first phase provide insights two important aspects of mobility practices. First, the results show the types of mobility practices in Malta and which other social practices interact with and influence mobility practices. Secondly, the data explores more deeply the mobility practices to reveal the constituent elements (material, competencies and meanings) of these and how other social practices influence mobility.

The results of the quantitative analysis of the survey data was important to demonstrate that the car is the preferred mode of travel amongst the population, while other modes such as using the bus, cycling and walking are less popular with the participants. The qualitative analysis found that there is an association between mode choice and the purpose of the trip. The use of the car for travelling to different activities was high amongst the responses of the travel survey. The data also showed how some of the activities to which individuals travel to are more dependent on the car than others. Other factors such as age, gender, nationality, having children, locality of destination and if the trip is performed on weekday or weekend influence the mode choice.

The qualitative analysis was based on the Theory of Social Practice as the guiding framework. The results show that each type of mobility practice is composed of a unique set of elements which include the physical materials such as the roads, the skills required to engage in such practices and the meanings that the individuals attribute to different practices. All the elements of the mobility practices are critical for the performance of the mobility practices.

The results have demonstrated how the car has an important instrumental function, that of allowing individuals to carry objects. This mode of travel is also perceived as convenient and offers flexibility for moving from A to B. Knowledge how to navigate to destination and avoid congested areas are essential skills of car driving. Using the bus presents a totally different set of elements. The lack of service provision is one of the (missing) elements of bus use. While the bus is perceived as being a stress-free mode of travel, a number of negative meanings were also associated with bus use including the lack of comfort, low levels of cleanliness and lack of personal space. In contrast, the meanings associated with active forms of travel and using the ferry are in general, positive. The interviews also reveal that there is room for improving the infrastructure related to walking and cycling. Some skills that would enable individuals to engage in active forms of mobility (for example knowledge of cycling) are also still lacking. The results were also important to show the influence of other social practices on mobility, where travelling to work and school, parental responsibilities, shopping and other social activities have an effect on mode choice and shape the recruitment of individuals to different forms of travel.

The results of this chapter are the starting point of the backcasting study which forms the basis of this research. Data on the current mobility practices serves to provide a framing of the problem and give an understanding of the challenges required to transition to more sustainable mobility. The next chapter, Chapter 6, will describe how these results were used to formulate alternative futures where mobility practices have been transformed into more sustainable ones.

# CHAPTER 6: TRANSPORT FUTURE VISIONS

*Part of the results of this Chapter have been published as a Journal article:*
*Camilleri, R., Attard, M., & Hickman, R. (2021). Future Low-Carbon Transport Scenarios: Practice Theory-Based Visioning for Backcasting Studies. Sustainability, 14(1), 74.*

## 6.1 Introduction

This chapter presents the set of future visions for the transport system in Malta for the year 2050. As detailed in the methodology section (Chapter 4), a fundamental step in the backcasting approach is the development of future visions which have the potential to meet sustainability targets. This Chapter covers the third objective of the research and answers the second research question namely *How can the current mobility practices be reconfigured into more sustainable forms?* It describes the main aspects of the participatory approach adopted to design alternative and more sustainable ways of carrying out mobility practices in the future. It also explains how the results from the participatory approach were developed into scenarios that describe three alternative transport futures. The details of alternative transport futures are also provided in this chapter.

The Chapter begins with outlining the outcomes of the participatory process highlighting the main aspects of the methodology employed during the development of the alternative future scenarios. It then demonstrates the usefulness of integrating the Theory of Social Practice with a participatory approach to develop futures where mobility practices are more sustainable. The chapter also discusses the scenario-generation process which used the concepts developed during the stakeholder workshop to build three alternative scenarios. It goes on to provide the details on the iterative process where stakeholders are not only involved in the visioning of alternative futures but are also engaged in the process of refining and improving the initial ideas into a set of concepts about the future of mobility practices. An in-depth description of the transport visions developed during the process and a comparative analysis of the three alternative future transport scenarios are also presented in the sections which follow.

## 6.2 The visioning workshop

### 6.2.1 The participants

The stakeholder visioning workshop constitutes the first phase of the multi-phase participatory backcasting process. The aim of the workshop was to develop future desirable scenarios depicting sustainable land-transport practices in the year 2050. The participative approach is an important aspect of the visioning phase of the backcasting process. The visioning workshop brought together a wide range of different actors all of which have an interest in transport or sustainability. The collaboration between the stakeholders was an important aspect to enhance the learning process within the participating group and foster better discussions. The participants of the visioning workshop represented normative actors that could contribute to envision more sustainable alternatives for the future of transport in Malta. The stakeholders represented different societal sectors as summarised in Table 6.1.

**Table 6.1: Participants in the visioning workshop.**

| Sector | Visioning workshop representatives |
|---|---|
| **Public and State** | National Energy Regulator (3)<br>National Environmental Authority (2)<br>National Transport Regulator (1)<br>Department of Transport and Infrastructure (1)<br>Climate Change Directorate (1) |
| **Private** | Members of the public (1)<br>Independent Cyclist (1)<br>Public Transport Operator (2)<br>Architects and Civil Engineer (1) |
| **NGO/Research** | Academics (1)<br>Researchers (4)<br>Environmental NGO (3) |
| **Demographics** | **Number of stakeholders** |
| **Gender** | Male (12)<br>Female (9) |
| **Age** | 18-35 (11)<br>35-50 (6)<br>> 50 (6) |

*Source: adapted from Camilleri et al. (2021)*

All stakeholders had high interest in the field of transport or climate change mitigation and had high levels of expertise in their respective disciplines. Table 6.2 provides further information on the workshop participants including their background, relevant sector and profession.

**Table 6.2: Visioning Workshop Participant Profile**

| | Participant Number | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| **Stakeholder group** | | | | | | | | | | | | | | | | | | | | | |
| The public | | ✓ | | | | | | | | | | | | | | | | ✓ | ✓ | | |
| Practitioners and experts | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ |
| Scholars and theorists | | | | | | | | | ✓ | | | | | | | | | | | ✓ | |
| **Professional Domain** | | | | | | | | | | | | | | | | | | | | | |
| Transport | | ✓ | | | ✓ | ✓ | | | | | | ✓ | ✓ | | ✓ | | | | | | |
| Environment | ✓ | ✓ | | ✓ | | | | | | ✓ | ✓ | | | | | ✓ | ✓ | | | | |
| Energy | | | | | | | ✓ | ✓ | | ✓ | ✓ | | | ✓ | | | | | | | |
| Planning | | | | | ✓ | | | | ✓ | | | | | | | | | | | | |
| University | | | | | | | | | ✓ | | | | | | | | | | | ✓ | |
| Climate Change | | ✓ | | | | | | | | ✓ | ✓ | | | | | | | | | | ✓ |
| Other | ✓ | | ✓ | ✓ | | | | | ✓ | ✓ | | | | ✓ | | | | ✓ | ✓ | | |
| **Type of Organisation** | | | | | | | | | | | | | | | | | | | | | |
| Administration | | | | | | | ✓ | ✓ | | | | ✓ | ✓ | | | ✓ | ✓ | | | | ✓ |
| Interest group | ✓ | | | | | | | | | | | | | | | | | | ✓ | | |
| NGO | ✓ | ✓ | | | | | | | | | | | | | | | | ✓ | | | |
| Research | | | | | | | | | ✓ | | ✓ | | | | ✓ | | | | | ✓ | |
| Private company | | | ✓ | | ✓ | ✓ | | | | | ✓ | | | | | | | | | | |
| Public representative | | | | ✓ | | | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | | | | | ✓ | | |
| **Age** | | | | | | | | | | | | | | | | | | | | | |
| < 18 | | | | | | | | | | | | | | | | | | | | | |
| 18 – 35 | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ | | ✓ | ✓ | | | |
| 35 – 50 | | ✓ | | | | | | | ✓ | | ✓ | ✓ | | | | ✓ | | | | | ✓ |
| > 50 | | | | | | | | | | ✓ | | | | | | | | | ✓ | ✓ | |
| **Gender** | | | | | | | | | | | | | | | | | | | | | |
| Male | ✓ | | | ✓ | | | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| Female | | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | | ✓ | ✓ | | ✓ | | | | | |

### 6.2.2 Creating transport future visions

The visioning workshop served as a space where the stakeholders could come together to discuss the critical issues around the current mobility practices in Malta. The face-to-face workshop provided a platform where the stakeholders could interact together to design futures for transport in Malta which are more sustainable. The first part of the workshop was set to introduce the participants with the current state of mobility in Malta, the unsustainable trends of the sector and the Malta's targets for climate change mitigation. Participants were made aware of the fact that if the mitigation targets for Malta were to be met, the transport sector had to reduce emissions by 80% of the current levels by 2050. They were also provided with the results of the first phase of the research (presented in Chapter 5), which described the current mobility practices in Malta in terms of their constitute elements (materials, competencies and meanings). The participants were also presented with the results showing the influence of everyday choices on mobility in Malta. These presentations were intended to frame the sustainability problem and act as a point of departure for the visioning workshop.

Against this background, the participants were asked to imagine a future in 2050 in Malta where the transport system is sustainable and the GHG emissions from the sector have been significantly reduced.  The problem definition helped the participants to understand the key challenges and understand the magnitude of change required if the targets for more sustainable transport are to be achieved. It was also useful to make participants understand that given the required degree of change needed to achieve sustainability targets, long-term planning is required with changes starting now. The visioning exercise resulted in a list of concepts depicting a different future. These concepts were screened by the researcher during the workshop and similar ideas were grouped together. The clustering exercise resulted into two different groups of concepts. On the one hand, there were those visions where a sustainable future was the result of technological innovations. In contrast, the other group of concepts showed visions of sustainable transport where active travel was at the centre of mobility and urban planning. These concepts are summarised in Table 6.3.

**Table 6.3: Sustainable transport future concepts identified by workshop participants**

| | |
|---|---|
| Technological change | |
| Using Artificial Intelligence (AI) | Electrically powered ferries |
| Autonomous cars | Electric bus transport and rapid bus transport. |
| Driverless transport | No ICE vehicles |
| System of "transport pods" moving around and between cities | The energy consumed is turned to kinetic energy is re-collected and re-used |
| Alternative fuels | Electric vehicles, electric bikes, prioritised public transport. |
| Hydrogen fuel | |
| Tailor made mobility machines | Movement of goods around urban areas through narrow tunnels and with drones. |
| Electronic personal watercraft | |
| Active forms of travel | |
| Wide open roads for the use by people walking, cycling and using public transport. | Arterial tramways through no traffic or limited traffic zones. |
| Car free | Street designs prioritise pedestrians and shared transport. Reduced space for parking infrastructure. |
| Quality public transport for longer distances, quality walking for shorter distances. | No private car ownership. Main transport through buses and minibuses, which would be extremely frequent, free and green. |
| Practical alternatives to private car use | All local services are at a walking distance. |
| Safe, planned and balanced with nature | Reduce the need to travel |
| Inclusive, so everyone can safely use the existing transport infrastructure regardless of the mean of transport they use. | Including transport that involves the human body as focus is on all-round well being. |
| Compact, dense urban environment where the quality of life is ensured by the accessibility of mixed uses and a focus on the quality of the public realm for sustainable transport modes and social functions. | |

The images of the future presented by the stakeholders did not comprise one single and coherent idea about what the future should look like. There was no one single shared vision of what a sustainable future might be. Rather, the images were composed of a set of different ideas on how the transport in Malta could look like in the future. Despite the lack of a unified image of the future, similarities between different concepts could be noted. The results indicate how the participants accentuate the role of technology in the decarbonisation of transport and how this could contribute to emission reduction in the future. From the perspective of the participants, improved spatial planning and an emphasis on active modes of travel could also offer a sustainable future for transport in Malta. Moreover, the exercise was important to show how a participatory approach to visioning can bring together diverse concepts on the concerns and challenges of the current problem and a shared exploration of what can contribute to a better and more sustainable future.

During the workshop, it was also noted how the use of interactive on-line tools such as *Mentimeter*, facilitates the discussion between participants and encourages the stakeholders to view the perspectives of the other participants in real-time and promote higher-order learning. The visioning exercise was aimed to stimulate the stakeholders to think about a future which is independent of the current trends and which would have been very different from the current situation. This long-term visioning was necessary to enable participants to think outside of the structures that shape the current mobility patterns and consider the significant changes that are required to reach sustainability goals. It was also noticed how some of the participants found this long-term visioning problematic. Similar methodological issues were encountered in other backcasting studies on sustainable transport (Soria-Lara et al., 2017b). This situation mainly arose since most were unfamiliar with the process of visualising long-term desirable futures. Some of the participants found it problematic to describe a future which is so distant from the present and imagine how things might change. To avoid and minimise the impact of this problem the research team used an example from other long-term transport visioning processes adopted elsewhere (Office of Science and Technology Foresight Programme, 2006).

During the process the participants were reminded often that they needed to envision a future for the year 2050. It was also important that the participants were visualising alternative futures rather than thinking of likely futures. This normative visualisation was crucial for the backcasting process which is based on defining desirable futures. One solution was the constant reminder by the researcher team, who guided the participants to propose images of the future which are desirable rather than probable.

### 6.2.3 Using social practice theory to develop transport visions

The concepts of future mobility and transport created by the participants were used as the point of departure for developing transport future visions based on a social practices approach. Two main themes emerged from these concepts. One theme included those concepts which focused on technological change, while the other focused on active travel. These themes were set as the axis for scenario development.

As outlined in Chapter 4 (Section 4.6.2), the participants were guided to think about how the current mobility practices would have to change in the future. The research team prompted the participants to discuss how the elements of the mobility practices (materials, competencies and meanings) would need to be reconfigured. In addition, stakeholders were asked to think about other social practices (for example shopping) that have an influence on mobility and how they would be different in the images of the future they created. They were also asked to think about innovative mobility practices that could be developed in the future. This exercise produced a set of eighty-three (83) concepts which are summarised in Table 6.4 and shown in Figure 6.1.

**Table 6.4: Concepts developed during the visioning workshop**

| Type of Concept | Concept | Frequency with which the concept was mentioned |
|---|---|---|
| **Materials** | | |
| Transport Infrastructure | New mass transport infrastructure including transport capsules and underground system | 6 |
| | Connected and autonomous vehicles (CAVS) | 2 |
| | Infrastructure for walking and cycling | 8 |
| | New fuels | 1 |
| | Innovative means of transport for goods deliveries | 6 |
| | Charging and repair points for CAVS | 4 |
| Planning | Urban planning which prioritises pedestrians | 5 |
| | Compact urban planning | 2 |
| | Car free zones and parking meters | 9 |
| Incentives for low-carbon transport | Multi-modal integration | 2 |
| | Teleworking facilities and reduced working hours | 6 |
| | Cycling facilities at workplaces | 2 |
| **Competencies** | | |
| Awareness programmes | Awareness on actual walking distance and route planning | 3 |
| Educational programmes | Training focused on use of new transport means | 3 |
| | Training on bicycle use and repair | 2 |
| | New mobile applications for use of shared services | 4 |
| | Education on how ICT can facilitate transport | 5 |
| **Meanings** | | |
| Design of transport system | Mass transport designed to prioritise personal space | 1 |
| Promotion and awareness raising | Promotion of active mobility as efficient, low-cost and beneficial to health | 4 |
| | Walking programmes for communities to combine transport and socialising | 1 |
| | Promotion of tele-working and flexi hours for low-carbon commuters | 3 |
| | Road enforcement which makes roads safer | 2 |
| Incentives / disincentives | Tax incentives to promote active walking and disincentive car use | 2 |

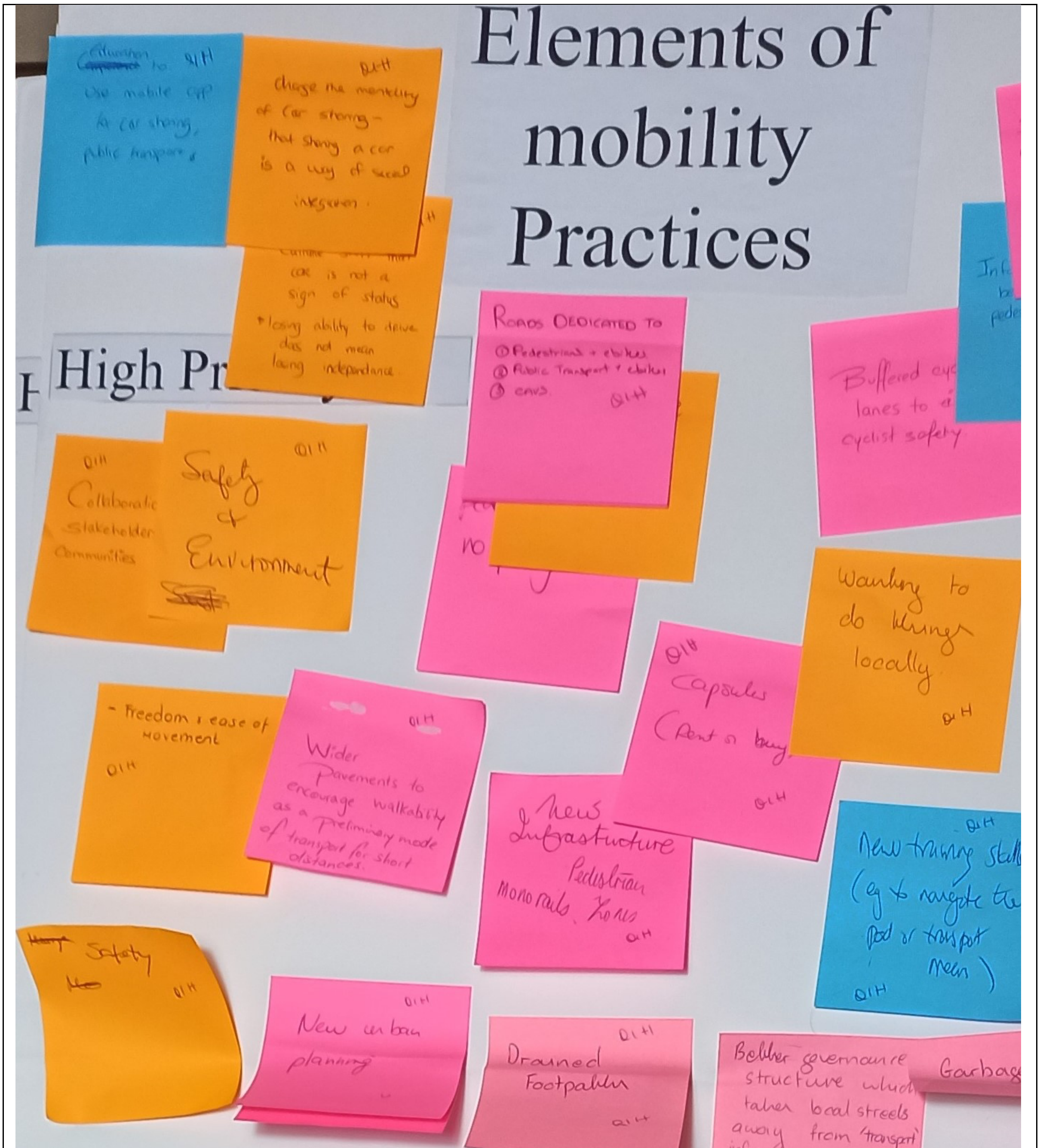



**Figure 6.1: Examples of concepts generated by the stakeholders during the visioning workshop**

These concepts included a range of ideas about how sustainable mobility futures would look like. For example, the stakeholders mentioned how a sustainable future would include an efficient mass transport system. Others discussed how teleworking would be an important aspect of a more sustainable transport future. Other ideas included improvement in walking and cycling infrastructure together with training programs and increased awareness for the promotion of active modes of travel. Compact urban planning, better road enforcement and car-free zones were also amongst the concepts generated by the stakeholders during the visioning workshop.

In Table 6.4 the concepts generated by the stakeholders were grouped under broader categories (Type of Concepts) for the purpose of summarising the results. These concepts are further grouped under materials, competencies and meanings.

It can be observed how the materials set of concepts make up the majority of the ideas generated. Concepts related to competencies and meanings (17 and 13 respectively) make up a smaller part of the ideas generated during the workshop. This observation, in part, reflects the current emphasis on technological solutions for decarbonisation (Banister et al., 2012; Schwanen et al., 2011). It may also suggest the difficulty amongst stakeholders to think beyond technology and infrastructural change. The results may also suggest that, despite the guidance offered by the research team, the participants found it difficult to think beyond material elements and to focus on the meanings and competencies that are needed for transition to more sustainable forms of mobility.

Among the most common changes to the material elements suggested by the stakeholders were changes in urban planning to restrict use of the car and improvement of the infrastructure that would promote active forms of travel. The concepts developed by the stakeholders also show their perspective on the need for innovative modes of transport both for the transport of people but also for the movement of goods. The ideas generated include a system of transport capsules, an underground system and the introduction of connected and autonomous vehicles (CAVS). An improved system of urban planning which prioritises active forms of mobility and allocates more space for pedestrians rather than the car was seen as an important aspect of a sustainable transport future. The concepts put forward during the visioning phase also featured changes to the work environment such as the provision of teleworking facilities that reduce the need for commuting. Cycling facilities at the workplace were also amongst the material elements which the stakeholders identified as important for sustainable transport futures to be achieved.

The results in Table 6.4 are also important to illustrate how using a Theory of Social Practice approach to guide the visioning process can produce concepts and ideas about what could contribute to sustainable transport in the future, which go beyond the provision of infrastructure and other material elements. Despite that the stakeholders initially found it challenging to think beyond the material elements, with the guidance of the researcher, concepts related to competencies and meanings also emerged. These reconfigurations of competencies and meanings are often overlooked in contemporary transport planning but are important for the performance of sustainable mobility practices.

The concepts put forward by the stakeholders when they were asked to think about how images of a sustainable future can be achieved, included a set which focus on the skills required to enable individuals to engage in new forms of practices. For example, awareness on actual walking distances and information on how one can plan a route to reach the destination on foot is perceived by the stakeholders as vital in addition to the walking infrastructure for the uptake of walking. Similarly, the participants suggested how providing individuals with skills for cycling is critical for the uptake of cycling in the future. This, in the context of an island where the level of cycling skill is very low (Transport Malta, 2016a). The use of ICT and mobile applications (digitalisation) which facilitate mobility was also seen as an important skill in a future where transport is sustainable.

During the workshop the stakeholders also reflected on the meanings related to mobility practices and how these should change from the current situation if a sustainable transport future is to be achieved. The participants discussed how a feeling of safety is important to help the transition to low-carbon travel. Active mobility should also be promoted as low-cost and of benefit to health. The stakeholders also identified how the design of the public transport system should prioritise personal space, which is an important aspect of traveling with public transport. According to the participants, a sustainable transport future is one where low-carbon modes of travel are incentivised while car use is disincentivised.

### 6.2.4 Scenario development

The visioning workshop resulted in a good number of concepts to enable the development of a set of alternative scenarios describing sustainable transport futures in Malta. The scenario development phase can be described as the process through which the concepts from the visioning phase are assembled together in complementary ways to construct a set of distinctive scenarios showing how mobility practices will take place in the year 2050. Whilst the individual concepts would signify minor changes to the current mobility practices, when these are combined into alternative scenarios, more drastic and significant changes emerge.

The scenario development in this study was based on the 2 x 2 scenario matrix methodology (Bradfield et al., 2005; Ramirez et al., 2014). This technique involved the identification of two critical and uncertain factors which are then used to set the axis around which the scenarios are modelled. There are various methods through which the axis of the scenario matrix may be identified. These can be deducted from quantitative analysis, inducted from a qualitative inquiry process, or identified from an iteration of both quantitative and qualitative inquiry (Ramirez et al., 2014).

When developing the scenarios during this phase of the research project, the axis reflected the two distinctive themes which emerged during the creativity session. During the creativity session, the participants were asked to imagine a future in 2050 in Malta where the transport is sustainable. The results (Section 6.2.2), show that most of the ideas generated during this session fall under two categories; one which describes technological change and one where active travel is given priority over other forms of transport.  These categories were used to define the axis of the scenario matrix as shown in Figure 6.2.

| | |
|---|---|
| Scenario 1<br>High Technology / Low Active Travel | Scenario 2<br>High Technology / High Active Travel |
| Scenario 4<br>Low Technology / Low Active Travel | Scenario 3<br>Low Technology / High Active Travel |

**Figure 6.2: The 2 x 2 Matrix for Scenario Development**

The concepts identified using a Theory of Social Practice approach were clustered under the matrix shown in Figure 6.2. After carrying out the analysis for each of the concepts created during the visioning workshop, four future scenarios were created. One of the scenarios – low technology / low active travel (Scenario 4) represented the business as usual (BAU) scenario. This scenario represents a future with little investment in infrastructure which enables active modes of mobility. In this future the demand for travel continues to increase, technology also improves however this improvement in not enough to counteract the increased demand for travel. The other three scenarios represented alternative scenarios which are more sustainable than the BAU and are more suited to achieve the desired emission reduction targets (80% reduction by 2050). Each of the scenarios included a mix of concepts related to changes in material elements, competencies and meanings in mobility practices and thus provide a complete transformation of all the elements which shape future practices.

The concepts grouped under different scenarios were further developed by the researcher into preliminary scenario narratives (Figures 6.3 to 6.5) . These narratives describe the alternative transport futures for Malta in the year 2050. The narratives represent storylines which depict how mobility practices would have changed through reconfiguration of the elements of these practices and introduction of innovative elements of practices. The narratives present descriptions which are intended to provide a picture of what mobility would look like under each different scenario. These preliminary scenarios were distributed amongst the stakeholders for further feedback as described in the next section.

**Scenario 1**

*This scenario describes a future where people still feel the need for more travel. Individuals have very busy lifestyles and are moving fast from one point to another. However, technology has evolved in such a way as to allow this fast movement while at the same time reduce the emissions generated from the road transport sector.*

*In this scenario, transport consists mainly of connected and autonomous vehicles which are shared (CAVs). The CAVs are electrical and are powered by electricity coming from renewable resources. When they are parked, the vehicles are charged and also undergo any repairs and maintenance which is necessary. Through various educational programs set in place, individuals are capable of operating and using the CAVs very easily. Sharing of trips in CAVs serves also as a means of social integration where individuals are no longer isolated within their personal car but can socialise during their day-to-day travel. A small number of individuals still make use of the car for personal travel.*

*Transport capsules characterise the mass transport system. These capsules, are suspended above ground and are powered by solar panels on the roof of the capsules. A network of capsule lines allows very fast movement of people from one place to another. CAVs are connected to the capsules to allow for easy transfer from one mode to another. Another capsule system runs in parallel underground and is used for the transport of goods.*

**Figure 6.3: Scenario 1 – Preliminary narrative**

**Scenario 2**

*In this scenario, technology has enabled individuals to adopt a lifestyle where they travel less or make use of active forms of mobility. Workplaces have been equipped with video-conferencing facilities. Employees have less stringent times during which they need to be at the workplace. The automation of many processes and the development of technology facilitates work from home. This has greatly reduced the need to travel to and from the workplace. Where travelling is necessarily, this is done through communal transport which companies provide for free to their employees.*

*Tertiary education is based on e-learning and in this way students need to spend less time on campus. They need to commute less to University and this reduces the number of trips. IT technology has improved and this makes e-learning an enjoyable experience for students. Educational programs aimed at improving IT skills have facilitated the use of mobile applications for public transport. With these applications individuals can plan the best route and have information in real time on the location of the bus, so that they can plan their journey more effectively without losing time.*

*Electric scooters and mobile walkways help individuals to travel over short distances. People have learnt that the car is no longer a sign of status. Travelling for shopping is reduced by an autonomous underground system which delivers goods. Other goods which are not delivered through this system are transported and delivered by drones. For longer travel distances, the individuals can opt to take cable cars or travel pods. These are powered by electricity which comes from renewable resources.*

**Figure 6.4: Scenario 2 – Preliminary narrative**

**Scenario 3**

*The urban environment has been designed to provide a green environment where active travel is prioritised over other forms of transport. Urban planning is now such that there is a network of green spaces. Individuals can now walk between these interconnected green spaces using footpaths which are wide, safe and free from obstructions.*

*The urban community is well aware about the health benefits of active travel over other modes of transport. Tax benefits are in place for those who chose to travel using active modes of travel including walking and the electrical bicycle. Signs along walking paths which show actual distances between localities provide pedestrians with the knowledge about the actual distances and the best route they need to take. Buses are available at the periphery of this new urban plan and they run on separate lanes than those used for walking or cycling.*

*Low-emission zones and parking taxes mean that the use of cars is greatly discouraged. They are also segregated at the periphery of the urban environment. However, other forms of travel are preferred.*

**Figure 6.5: Scenario 3 – Preliminary narrative and image**

### 6.2.5 Scenario feedback and elaboration

The preliminary scenario narratives were distributed with the stakeholders for further feedback and elaboration. The stakeholders could comment and provide additional input on the scenarios via an online survey. This step is considered important in the participatory visioning and backcasting process as it enhances the engagement of stakeholders and stimulates ownership of the visions amongst stakeholders (Doyle et al., 2013; Mander et al., 2008a). The stakeholders were asked to list any aspects of the scenarios that they would like to change. They were also asked to include recommendations for additional concepts or ideas which could be included in the scenario.

Fourteen out of the 21 stakeholders which participated in the visioning workshop responded to the survey and submitted their feedback on the preliminary scenarios (a response rate of 67%). The response rate demonstrated a good level of feedback amongst participants and resulted in useful recommendations for improving the preliminary scenarios. In their feedback the stakeholders recommended that in the first scenario, the capsules are located underground rather than over-head due to the current urban landscape. From the stakeholders' suggestions, the relocation of the capsule system to underground would avoid a negative aesthetic impact on the environment. The mass transport system should also be designed in such a way as to be comfortable, allowing a good level of personal space and allows individuals to be productive while travelling. The stakeholders also recommended the addition of a fully electrical bus fleet with segregated lanes that would complement the capsule system described in first scenario. In their suggestions they also stated that cycling should be promoted as part of the transport system in the future transport scenario one.

The stakeholders also provided feedback on the second of the transport future scenarios developed in the previous stage, one where the improvement in ICT allows for more teleworking and reduces the need to travel. The stakeholders suggest that in addition to the concepts described in the narratives, the scenario should include more emphasis on travel for other activities other than the commute. The participants also recommend that the scenario should focus on mitigating social isolation that might be induced by tele-working or studying remotely. A number of recommendations were also made by the stakeholders for the third future transport scenario. This scenario received positive comments from most of the stakeholders, with some stating that this is their most preferred transport future. Stakeholders commented that for this scenario to be effective, a dense network of public transport services must be developed to ensure an efficient system. Another recommendation for this scenario was the inclusion of an autonomous shuttle bus that services localities and enables local travel.

The feedback collected from the stakeholders' survey was used to refine the preliminary future scenarios described in previous section. This process led to the formation of a final set of three transport future scenarios. Although similar to the initial set of scenario narratives, the refined version of the scenarios incorporate the stakeholder feedback, thus enhancing the sense of ownership of the stakeholders towards the scenarios. Each of the scenarios was assigned a name, which reflects the narrative of the scenario and which allows easy reference in the next phases of the backcasting process. Scenario 1 was identified as *High Tech Mobility,* Scenario 2 named as *Local Active Mobility* and Scenario 3 *Green and Active Travel.* The final set of scenario narratives, including scenario names are presented in Figures 6.6 – 6.8.

**Scenario 1: High Tech Mobility**

*This scenario describes a future where the demand for travel is still strong. Individuals have very busy lifestyles and are moving fast from one point to another. However, technology has evolved in such a way as to allow the transition from private car to mass transit forms of travel. These are also powered with cleaner fuel thus enabling emission reductions from the sector.*

*Transport capsules characterize the mass transport system. These capsules and travel underground. A network of capsule lines allows very fast movement of people from one place to another. The network is designed is such a way as to allow for easy changes between other modes of transport. Bike sharing facilities are available close to the stops of the capsule lines and bicycles* *can be transported inside the capsules. In addition to the transport capsules a fully electrical bus fleet with segregated lanes provides quality public transport that together with the transport capsules provide transport corridors for the bulk of mobility needs. The capsules are highly efficient allowing easy travel between different sites of acclivities. The underground capsule system runs in parallel with an underground system for the transport of goods.*

*In this scenario, personal transport consists mainly of connected and autonomous vehicles (CAVS). The CAVS are electrical and are powered by electricity coming from renewable resources. When they are parked, the vehicles are charged and also undergo any repairs and maintenance which is necessary. Through various educational programs set in place, individuals are capable of operating and using the CAVS very easily. Sharing of trips in CAVS serves also as a means of social integration where individuals are no longer isolated within their personal car but can socialize during their day-to-day travel.*

*A small number of individuals still make use of the car for personal travel. However, these run on a new fuel which produces only small amounts of $CO_2$ relative to the conventional fuels.*

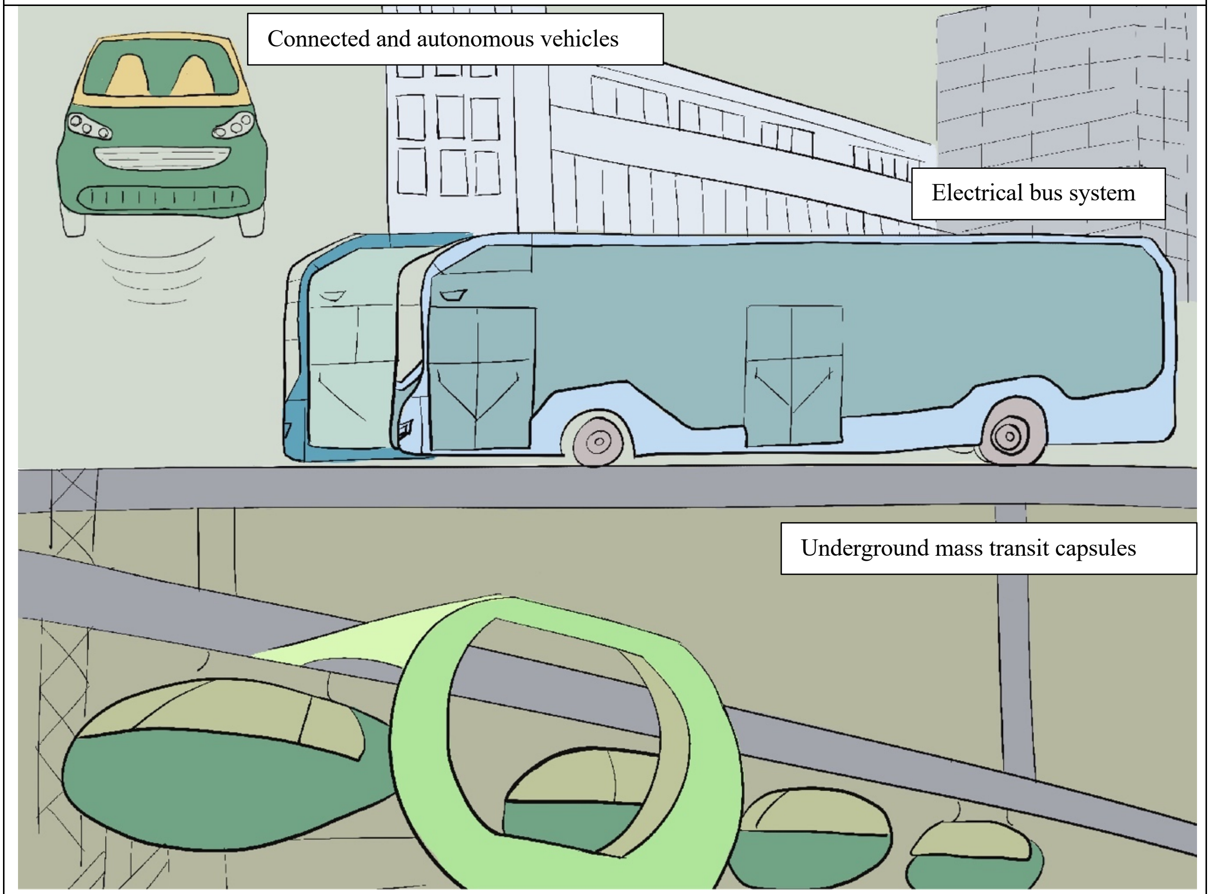



**Figure 6.6: Scenario 1 – High Tech Mobility**
*Source: adapted from Camilleri et al. (2021)*

**Scenario 2: Local Active Mobility**

*In this scenario, the use of technology is focused on enabling lifestyles with high mobility at the local scale through forms of active travel. This future illustrates a world where the need to travel over long distances to perform the daily activities has been reduced. Individuals are still mobile, however now they are traveling more locally over shorter distances.*

*An efficient IT infrastructure now permits businesses to shift part of their operations to remote working. Under this scenario, workplaces are equipped with video-conferencing facilities and employees have less stringent times during which they need to be at the workplace.*

*In this future, universities and high-level education institutions have integrated e-learning as part of their methods for education. Improvements in IT enables easy access to education and makes e-learning an enjoyable experience for students. Local centers complement the e-learning facilities. These centers provide a physical space where students can interact with each other.*

*Electric scooters and travel escalators help individuals to travel over short distances. People have learnt that the car is no longer a sign of status. Shopping for goods over the internet is largely promoted and helps reduce the number of trips to large supermarkets. Goods are delivered to homes via clean based transport modes.*

*Travel for other activities such as childcare and social activities can take place through electric vehicles, where a managed fleet of autonomous vehicles are available for select trip purposes. These are not owned privately but managed centrally or through MAAS services (highly regulated). Private cars are electric and are used for long distance travels. These cars are not allowed in low-emission zones and town centres. Electric scooters, electric bicycles and mobile walkways help individuals to travel over short distances. People have learnt that the car is no longer a sign of status. Travel over longer distances is facilitated by a dense network of public transport. Educational programs aimed at improving IT skills have facilitated the use of mobile applications for public transport. With these applications individuals can plan the best route and have information in real-time on the location of the bus, so that they can plan their journey more effectively.*

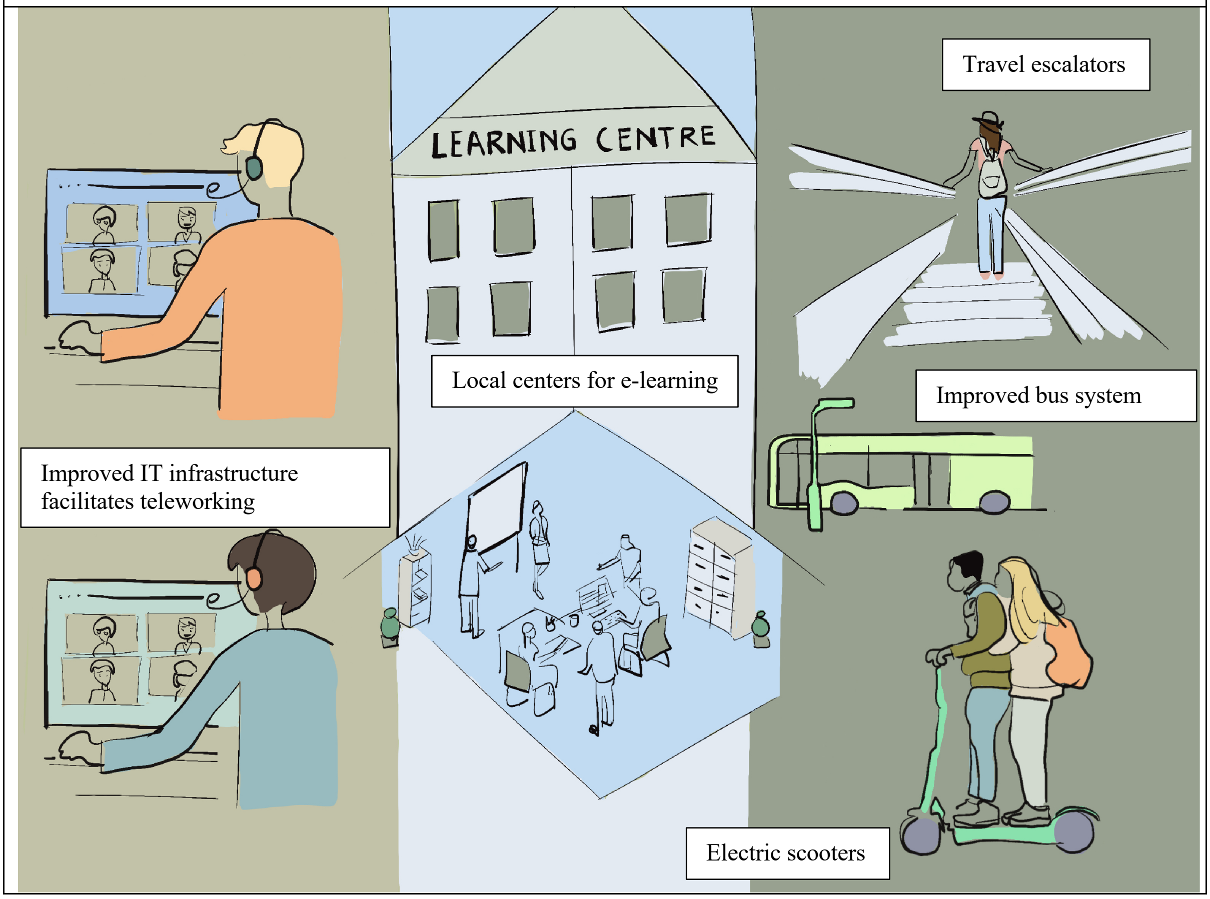



**Figure 6.7: Scenario 2 – Local Active Mobility**

*Source: adapted from Camilleri et al. (2021)*

**Scenario 3: Green and Active Travel**

*This future focuses on an improved urban design that priorities active travel over other forms of transport. A network of interconnected greenspaces with paths which are wide, safe and free from obstructions facilitates active travel such as walking.*

*The urban community is well aware about the health benefits of active travel over other modes of transport. Tax benefits are in place for those who chose to travel using active modes of travel including walking and the electrical bicycle. Low-emission zones and parking taxes mean that* *the use of cars is greatly discouraged. Signs along walking paths which show actual distances between localities provide pedestrians with the knowledge about the actual distances and the best route they need to take.*

*Buses are available at the periphery of this new urban form and they run on separate lanes than those used for walking or cycling. Buses connect towns together allowing for travel over longer distances. A dense network of public transport services means that the buses run on time and are frequent and can compete with the efficiency offered by the car. Inside the towns, autonomous electric shuttles are available, and these are connected to the bus system. This system of autonomous shuttles allows for people to carry out other activities such as social activities, carrying of goods from food stores and other work-related activities.*

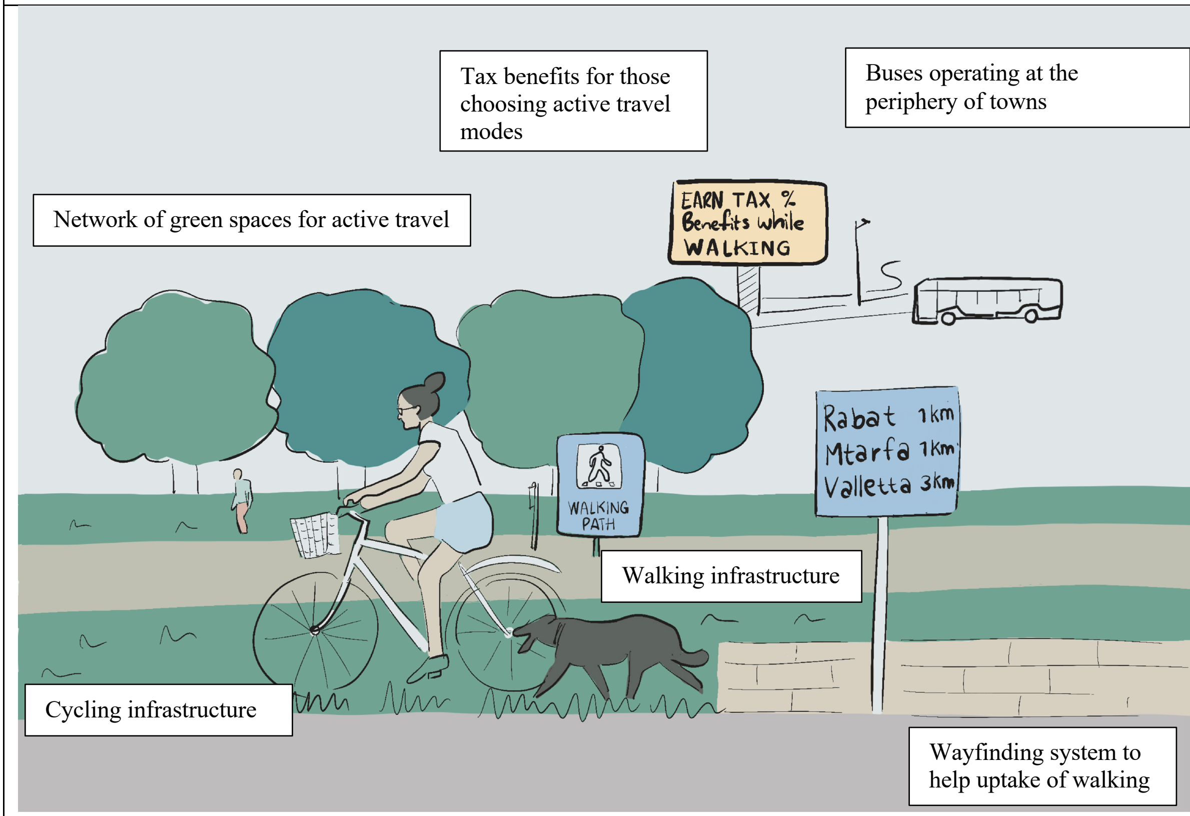



**Figure 6.8: Scenario 3 – Green and Active Travel**
*Source: adapted from Camilleri et al. (2021)*

The *High Tech Mobility* scenario (first scenario) depicts a future where the reduction in emissions comes from the result of modal shift from the private car to public transport. This scenario requires investments in a new public transport system which caters for the mobility needs of the individuals and allows the shift from car-based travel. Investment is also needed for a new and improved bus fleet which also characterizes this transport future. The scenario is also driven by high levels of technological change, where the introduction of connected and autonomous vehicles, which are electrically powered, and new fuels which are envisaged to reduce emissions from the sector. In this scenario, a dense network of mass transport services allows the provision of an efficient and reliable service which means that individuals can travel between sites of activities in a timely manner which can compete with the efficiency of the car.

Contrastingly, the *Local Active Mobility* scenario (second scenario) describes a future where emission reduction is achieved by reduced levels of travel. The focus is on ICT and technology which enables the individuals to carry out their activities within their neighborhood thus reducing the need to travel over longer distances. Movement over shorter distances is carried out with active modes of travel and micro-mobility. This scenario requires investment both in walking and cycling infrastructure, but also in ICT (digitalization) which would enable shift to online forms of working and other activities, which are facilitated by improvement in infrastructure.

The *Green and Active Travel* scenario (third scenario) prioritizes walking and cycling over car-based travel. The focus of this scenario is on urban planning where habitats are reconfigured and where space allocation gives priority to pedestrians and cyclists. The scenario also reflects an investment in public transport, in addition to urban planning and public transport investment.

The scenarios created during the visioning workshop are similar to other studies which have used backcasting to develop alternative and more sustainable transport futures (Soria-Lara et al., 2017b; Tuominen et al., 2014). In these studies, a set of futures describe a transport system where technological improvements would lower $CO_2$ emissions from the sector while at the same time providing mobility needs for the population. Other visions are based on the concepts of compact cities and modal shift from car-based travel to low-carbon means of transport.

The innovation in this study is the application of the Theory of Social Practice, which identifies the importance of elements which go beyond the material elements of mobility and take into account the importance of competencies and meanings that shape mobility practices. For example, scenarios two (*Local Active Mobility*) and three (*Green Active Travel*) in this study, both focus on a shift from car-based travel to active forms of mobility. In these scenarios, the provision of appropriate infrastructure that would facilitate active forms of travel is an important aspect of the scenario narrative. However, the practice-based scenarios also include aspects that target the reconfiguration of competencies and meanings. The wayfinding system in one of these scenarios is one example of how new competencies, which are essential for walking, are introduced. The provision of information on the actual distance individuals need to walk, facilitates the shift from car-based by influencing their understanding of the space-time relationships in travel. Similarly, scenario one (*High Tech Mobility*) recognises how a shift from car to public transport modes of travel are not only shaped by bus provision but are also influenced by meanings of efficiency and reliability which individuals value and which influence their choice of travel. An efficient public-transport service that competes with the efficiency of the car and ICT skills that would allow users to plan their journey effectively can start to make significant changes and shifts from private car use to other low-carbon modes of travel.

## 6.3 Conclusion

This chapter has described the visioning process through which a group of stakeholders were engaged to develop a set of alternative transport futures which reflect a change in mobility practices. The participatory approach was a fundamental aspect of the process where a range of participants, with different backgrounds, skills and expertise and an interest in transport were invited to envision a future in 2050 in Malta where transport would be sustainable. The Theory of Social Practice was used to guide the visioning process which resulted in the development of four transport future scenarios. One transport future depicts the business-as-usual scenario while the other three futures illustrate alternative futures in which transport is more sustainable. These scenarios present futures where many of the elements (materials, competencies and meanings) of mobility practices have been reconfigured.

The next chapter, Chapter 7, will look at the potential emission reduction potential that each of the alternative future scenario presents.

# CHAPTER 7: SCENARIO SUITABILITY EVALUATION

## 7.1 Introduction

This chapter presents the results of the evaluation of the alternative future transport scenarios. It covers the third objective of the research and answers the third research question namely; *What are the likely impacts of such reconfigurations on $CO_2$ emissions from transport?* The participatory practice-based visioning exercise, presented in Chapter 6, produced three alternative transport future scenarios. This chapter describes the next stage in the backcasting process which involves the evaluation of the relative emission reduction potential of each of these scenarios. A transport modelling exercise was at the basis of the scenario suitability assessment.

The chapter begins with outlining the results of the modelling process used to determine the suitability of the alternative transport future scenarios. These outcomes will be presented in terms of $CO_2$ emission trends that span from the year 2018, which represents the base year for this study, to the year 2050. The chapter then goes on to compare the emission trends of each of the alternative scenarios with the emission estimates which are expected for the business-as-usual scenario. The chapter then concludes with a comparative analysis which includes all three alternative future scenarios. Such comparative evaluation is important to highlight the strengths and weaknesses of the alternative scenarios and provide an idea of their impact should they be implemented.

## 7.2 Modelling $CO_2$ emissions

### 7.2.1 The transport emission model

This phase of the backcasting study consisted in the evaluation of the alternative future scenarios with respect to their potential in reducing emissions from the transport sector in Malta. The evaluation of the alternative transport scenarios was based on the UNECE model ‘For Future Inland Transport Systems (ForFITS) model (https://unece.org/forfits-model-assessing-future-co2-emissions). ForFITS allows the assessment of possible impacts of different developments in the transport system on the demand for public and private transport, the intensity of use by mode, energy consumption and GHG emissions. The main aim of the ForFITS model is the assessment of long-term GHG emissions in transport and evaluation of transport policies. The model is a sectorial model allowing for the estimation of several different changes in land transport. It includes all major transport modes and is capable of distinguishing between different vehicle categories and powertrain technologies. It also allows the input of various macro socio-economic parameters which have an effect on transport. The model has been tested for its usefulness for scenario evaluation in several countries (T. Andrejszki et al., 2014; Marc Georges Haddad et al., 2018; E. Menezes, AG. Maia, et al., 2017; J Zawieska et al., 2018).

The details of the ForFITS model, the assumptions made for the modelling exercise and the data used to model the emissions are described in the methodology section in Chapter 4 (Section 4.7.2). The model was used to forecast the $CO_2$ emission levels for the transport system in Malta from the year 2018 to the year 2050. The emission levels for transport were modelled under four different scenarios, each of which presents different assumptions and changes in the transport system. These are listed below and described in the following sections.

1. Business as Usual Scenario (BAU)
2. Transport Future Scenario 1: Tech Mobility
3. Transport Future Scenario 2: Local active Mobility
4. Transport Future Scenario 3: Green and Active Travel

## 7.3 The Business-as-Usual Scenario

Having established the methodology for evaluating the alternative transport future scenarios, the next step was to build and simulate the business-as-usual (BAU) scenario as a reference and against which the other scenarios would be assessed. The BAU serves as the basis for quantifying the potential of the alternative scenarios for reducing emissions and reaching the 80% reduction in $CO_2$ (which represents the target for this backcasting study).

### 7.3.1 Model parameters

This scenario represents a continuation of current trends in transport policies. The BAU assumes that there will be an improvement in vehicle technology and the average fuel consumed per kilometer travelled will decrease from the base year to the target year. This assumption was based on the EU regulations related to vehicle emissions (European Commission, 2019) and estimates that fuel consumption per vehicle kilometer will decrease by 2025 and 2030. The scenario also assumes a decrease in emissions due to an increase in the share of bio-fuels and increased reliance on renewable energy (European Commission, 2009a, 2009b). The BAU assumes there will be little change in the powertrain technology, with the uptake of electrical vehicles still being low when compared to conventional power systems. The scenario also assumes that there will be no implementation of taxes on fuel use and the environmental awareness amongst individuals that influences behavioral change remains the same as in the base year. Details of all assumptions made for modelling of the BAU scenario can be found in Section 4.7.2 (Chapter 4).

### 7.3.2 Results of the BAU scenario

In this chapter, the assessment of the alternative future scenarios against the BAU will be based on the comparison of two ForFITS output parameters namely the tank-to-wheel (TTW) $CO_2$ emissions and the activity intensity of the different modes:

1. Tank-to-Wheel (TTW) GHG emissions which represent the amounts of gases (in terms of $CO_2$ equivalent) which are generated from the consumption of fuel. These emissions represent the energy consumption from vehicle use.
2. Passenger kilometre (pKm) which indicates the yearly intensity of use of passenger transport modes (calculated as the number of passengers multiplied by the distance).
3. The activity intensity of the transport system for the different transport modes, calculated in vehicle kilometers (vkm).

Table 7.1 provides the outcomes of these two variables as simulated under the BAU scenario for the base-year (2018) and the target year (2050). These results represent the emissions from the transport sector currently and in the future, in the absence of new policy interventions. Figure 7.1 then illustrates how these output parameters vary across the period of analysis.

The results for the BAU scenario (Table 7.1) show how the activity intensity (in terms of vehicle kilometers) of the passenger transport system in Malta is estimated to grow considerably from the base year (2018) to the target year (2050). This growth under this scenario is a result of the projected growth in the population and the GDP. Table 7.1 is also useful to show that the highest degree of change in terms of activity is expected to be for light vehicles. This scenario assumes little policy interventions for road transport and as a result, the activity for light vehicles (including private cars) is set to nearly double by the year 2050. This increase is also reflected in the passenger transport activity, where Table 7.1 shows that in 2050 the number of passenger kilometers travelled will be much higher (nearly double) that in 2018.

This increase in vehicle activity and number of passenger kilometers travelled can also be observed from Figure 7.1.

**Table 7.1: BAU Scenario outputs for the passenger transport system in Malta.**

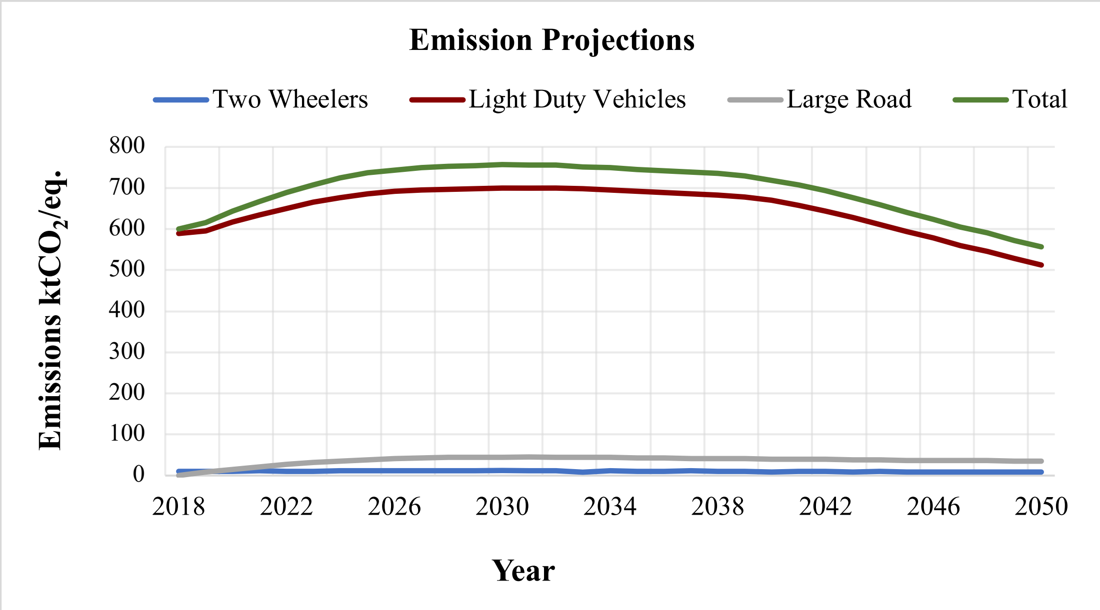
| Output Variable by Mode | Unit | Base year (2018) | BAU (2050) |
|---|---|---|---|
| TTW emissions – Light Duty Vehicles (LDVs) | $ktCO_2e$ | 589.0 | 512.5 |
| TTW emissions – Two Wheelers | | 10.3 | 8.6 |
| TTW emissions – Large Road (including buses and coaches) | | 8.6 | 35.6 |
| **Total TTW emissions** | | **607.9** | **556.7** |
| Activity Intensity - LDVs | vkm, billion | 4.7 | 8.2 |
| Activity Intensity – Two Wheelers | | 0.2 | 0.3 |
| Activity Intensity – Large Road | | 0.2 | 0.2 |
| Passenger transport Activity Intensity (LDVs, Two Wheelers) | pkm, billion | 5.7 | 9.2 |

*Own elaborations based on:* International Monetary Fund, 2019; NSO 2009, 2014, 2019, 2020; European Commission Directorate Genral for Economic and Financial Affairs, 2018, UNECE Transport Division, 2014, Hass et al., 2014, European Environment Agency, 2019, Enerdata Research Service, 2018.

The results presented in this section show that whilst the activity intensity increases between the base year and 2050, a slight decrease in the total tank-to-wheel (TTW) GHG emissions between the period of analysis is observed. Emissions are estimated to decrease from 608 $ktCO_2$ equivalent in the year 2018 to 557 $ktCO_2$ equivalent in 2050. This decrease occurs due to improved vehicular technology, and a reduction in the fuel emission factors between the base year and the target year. The outputs of the BAU simulations show that light duty vehicles contribute to the highest share of GHG emissions. This sector also shows greatest decrease in emissions. As observed from Table 7.1, results also show that emissions from large road vehicles which include buses and coaches are expected to increase between 2018 and 2050 rather than decrease as for the light duty vehicles and two wheelers. The BAU presented in this chapter is an optimistic scenario which assumes that technological innovation contributes to lower $CO_2$ emissions in the future.

The BAU presented is optimistic scenario and it is likely that emissions in 2050 are much worse than the ones projected. The assumed improvement in vehicle technology and electic vehicles will be slow to penetrate the vehicle market as a result of their high cost and no charging infrastructure.

**a. $CO_2$ emissions**




**b. Activity**

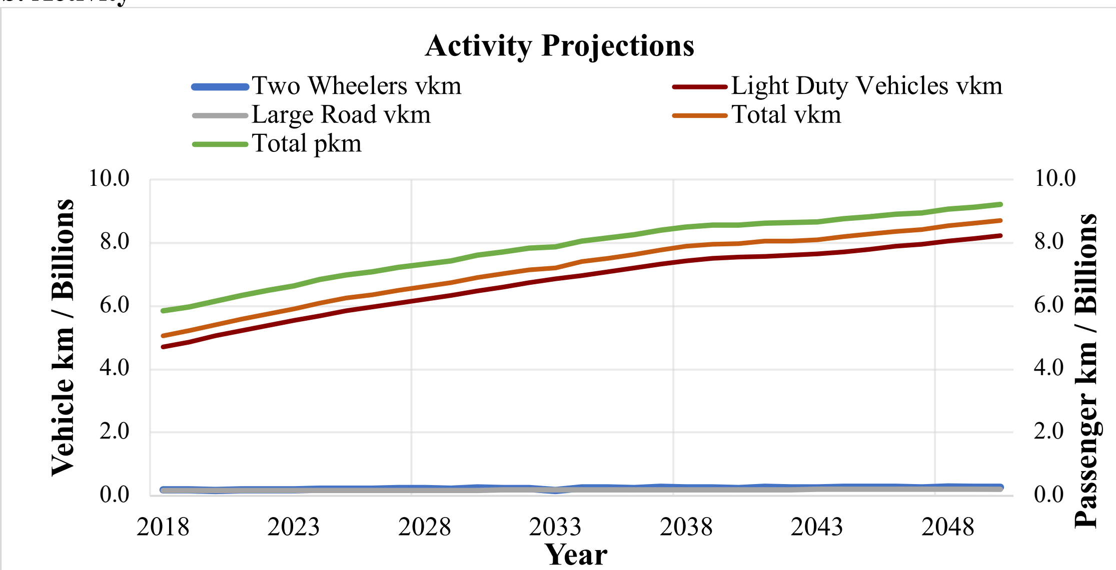



**Figure 7.1: BAU Scenario outputs.**

*Own elaborations based on: International Monetary Fund, 2019; NSO 2009, 2014, 2019, 2020; European Commission Directorate General for Economic and Financial Affairs, 2018, UNECE Transport Division, 2014, Hass et al., 2014, European Environment Agency, 2019, Enerdata Research Service, 2018.*

### 7.3.3 Validation of model outputs

Validation of the model outputs is critical to demonstrate the robustness of the modelling exercise which was carried out to estimate GHG emission trends from the road transport sector.

The validation of the model outputs for this backcasting study was carried out through the comparison with other independent studies which have also made projections for the GHG emissions from transport. One set of emission projections for the transport sector can be found in the national projections of GHG emissions which Malta reports to the European Commission as part of its obligations under the Monitoring Mechanism Regulation (European Commission, 2013). These projections show the levels of emissions up to the year 2040 by gas and by sector. These projections are calculated taking into consideration any policies and measures adopted at Union level. The reported data are quality checked by the European Environmental Agency (EEA) and its European Topic Centre for Air Pollution and Climate Change Mitigation (ETC/ACM).

A comparative analysis of the projections reported to the EU under Monitoring Mechanism Regulation and the projections resulting from modelling exercise for this study are presented in Table 7.2. The results presented in Table 7.2 show how for the base year (2018), the emissions modelled with ForFITS are concordant with the projections of GHG emissions from the transport sector for Malta submitted to the EU Commission. Estimations made with ForFITS show levels of GHG emissions at 599.6 kt$CO_2$e while national emission projections stand at 568.8 kt$CO_2$e.

Table 7.2 also provides a comparison of the outputs of the ForFITS model up to the year 2050 and the national GHG emission projections up to 2040. This data shows a small difference between the two data sets. The data from the ForFITS model is slightly higher than the national emission projections. The difference between the two estimations is due to the method used for modelling the emission levels. Estimation of $CO_2$ emissions in ForFITS are made based on the ASIF scheme where emissions are expressed as the product of vehicle activity (in vkm) (A), sectoral structure as shares of vkm by mode and powertrain (S), energy intensity as the average fuel consumption per vehicle type (I) and carbon intensity of the fuel type equivalent to the emission factors (F). On the other hand, emission inventory calculations are based on the demand for fuel and emission factors per type of fuel (Malta Resources Authority, 2019). Therefore, although the two estimations are similar, there are slight variations arising from methodological differences.

**Table 7.2: Validation of modelled results**

| Year of Projection | ForFITS Estimations | National Projections |
|---|---|---|

| | | (with existing measures) |
|---|---|---|
| | ktCO$_2$e | |
| 2018 | 599.6 | 568.8 |
| 2020 | 643.1 | 575.0 |
| 2025 | 736.6 | 563.6 |
| 2030 | 756.9 | 586.7 |
| 2040 | 719.0 | 558.0 |
| 2050 | 556.7 | |

**7.3.4 BAU Scenario and Climate Mitigation Targets**

The BAU scenario projects GHG emissions trends from transport from the base year to 2050, assuming minimum policy intervention aimed at reducing emissions. This scenario assumes some measures which target improvement in vehicle technology and higher fuel efficiency are in place by the target year. Under this scenario, the emissions are expected to increase from 2018 till 2032, after which a down-ward trend till 2050 is expected.

The percentage reduction in the GHG emissions from road transport in 2050, from the 2018 levels under these conditions, is 7.2%. In contrast, the target emission reduction from transport in 2050, required to meet the climate change mitigation targets, is 80% from the current levels. This significant difference between the projected reduction in emissions and the target percentage reduction highlights the difficulty that the sector faces in terms of climate change mitigation. In the absence of new policy interventions, the target goal of 80% reduction from the current GHG levels is a considerable challenge. The results presented in Table 7.1 are important to demonstrate that alternative policy scenarios aimed at bringing about more radical changes in the transport system are required if the set targets for emission reductions are to be achieved. Alternative scenarios such as the ones developed during the visioning phase of this backcasting study, may have the potential to reduce emissions and achieve the targets. The next sections will present the results from the evaluation of the alternative future transport scenarios and their potential in reducing emissions.

## 7.4 Alternative Future Scenario 1

The first alternative transport future scenario, *High Tech Mobility*, describes a future where the demand for travel has not been curbed. Personal transport has shifted from personal cars powered by conventional fuels to electrical powered vehicles. Where conventional fuels are still used, these are more efficient producing less emission per litre of fuel used. This scenario also includes an increase in the active modes of travel and a public transport system which is also operated using electrical energy (refer to Chapter 6, Section 6.2.5 for the full narrative).

### 7.4.1 Model Parameters

To model the $CO_2$ emissions under Scenario 1, an assumption was made that by the year 2050, the demand for personal transport would remain the same as in the BAU for the same year. However, the share of powertrain for vehicles would shift such as 20% of personal travel would be carried out using electric vehicles. The public transport fleet would also change from one which is based on conventional fuels to one which is powered by electrical power. To model the increased fuel efficiency under Scenario 1, the emission factors in ForFITS were reconfigured to reflect lower emissions per litre of fuel used. An estimated 10% decrease in emission factors was assumed when modelling this scenario.

The improved public transport system described in Scenario 1 would encourage modal shift from the private car to the public transport system. In ForFITS, the shift to increased public transport use can be simulated through changes in the input parameter "passenger transport system index", which parameter reflects the share of public transport in the system (UNECE, 2011; UNECE Transport Division, 2014). This parameter is important for the estimation of the demand for public transport and it allows to test the impact of public transport usage on emissions. The range of input variables allowed for this parameter is between zero and one. An index of zero would correspond to the case where all users rely on private means of transport. On the other hand, a value for the index which is close to one would indicate a system where most passengers make use of the public transport system (UNECE, 2011). In the BAU, the index was estimated by ForFITS based on the base year data for Malta. The estimation returned a value of 0.49, which shows that under the BAU conditions, there is a small share of passengers making use of public transport. A value of 0.7 for the transport system index is representative of an area with a high density of public transport and a high share of public transport use (UNECE, 2013). To simulate the conditions under Scenario 1, which include an improved public transport offer, the index was increased from the nominal value of 0.49 (used in the BAU) to 0.59, assuming a 20% shift. A similar approach and values for the transport system index has been used in other studies that have used ForFITS to model the improvement in the public transport system (UN Economic Commission for Europe, 2016; UNECE, 2013; J

Zawieska et al., 2018). Table 7.3 provides a summary of the different aspects of the scenario and the input parameters in the ForFITS model that were modified to estimate the emissions under such a scenario.

**Table 7.3: Model Parameters for Alternative Scenario 1**

| Scenario aspect | Description | Changes made in ForFITS parameters |
|---|---|---|
| Changes to main powertrain | An assumption was made that under this scenario, 20% of the vehicles for personal transport would be powered electrically | The shares of the different powertrains in the transport system was changed to reflect a shift to electrical power |
| | Under this scenario, the public transport system would be operated by means of a vehicle fleet 40% of which powered by electrical power | |
| Improvements in vehicle efficiency | Under Scenario 1, the fuels used to power the rest of the vehicular fleet would produce 10% less emissions | Lower emission factors were used to simulate better fuel efficiency |
| Improved public transport system | The public transport has improved under this scenario encouraging its use | 20% increase in passenger transport system index from base year |

### 7.4.2 Modelling outputs for Alternative Transport Scenario 1

The results from the simulation for future transport Scenario 1 are summarized in Table 7.4. The projections resulting from the modelling exercise for this scenario show that the total tank to wheel emissions are lower than those estimated for the BAU scenario. Alternative Scenario 1 depicts a future with a strong emphasis on technological change and improved public transport. These results demonstrate how a change in vehicle technology, coupled with an improved public transport system and more efficient fuels can lead to reduction in emissions.

**Table 7.4: Model Outputs for Scenario 1**

| Output Variable by Mode | Unit | Scenario 1 |
|---|---|---|
| TTW emissions – Light Duty Vehicles (LDVs) | ktCO$_2$e | 335.1 |
| TTW emissions – Two Wheelers | | 5.6 |
| TTW emissions – Large Road (including buses and coaches) | | 15.5 |
| **Total TTW emissions** | | **356.2** |
| | | |
| Activity Intensity - LDVs | vkm, billion | 5.3 |

| | | |
|---|---|---|
| Activity Intensity – Two Wheelers | | 0.2 |
| Activity Intensity – Large Road | | 0.15 |
| | | |
| Passenger transport Activity Intensity (LDVs, Two Wheelers) | pkm, billion | 6.0 |

*Own elaborations based on:* International Monetary Fund, 2019; NSO 2009, 2014, 2019, 2020; European Commission Directorate Genral for Economic and Financial Affairs, 2018, UNECE Transport Division, 2014, Hass et al., 2014, European Environment Agency, 2019, Enerdata Research Service, 2018.

## 7.5 Alternative Future Scenario 2

Future transport Scenario 2, *Local Active Mobility*, depicts a future where the use of communications technology allows for less travel for activities related to work and education. Travel for other activities occurs through electric vehicles and a system of low-emission zones in town centers has been implemented. Under this scenario, active travel has also increased and travelling for shopping is reduced through the use of online shopping (refer to Chapter 6, Section 6.2.5 for the full narrative).

### 7.5.1 Model Parameters

Alternative transport Scenario 2 presents a future with a strong emphasis on telecommunication which enables part of work-related activities and education to be shifted. This aspect of the alternative future was reflected in the modelling exercise which estimated the emissions under this scenario. Telecommunication facilities and information technologies (ICT) enable the dissemination of teleworking amongst those workers whose roles are possible to perform without the need for them to travel to a workplace. Literature has shown that teleworking offers the possibility to reduce commuting trips (Elldér E, 2020; Van Lier et al., 2014). Studies have also demonstrated that workers making use of teleworking, make fewer and shorter trips, are more likely to engage in active modes of travel. In addition, teleworking is also shown to contribute to the reduction of peak-hour traffic (Elldér E, 2020; Lachapelle et al., 2018). This reduction of travel distances and work-related trips has the potential of reducing $CO_2$ emissions from transport.

Modelling the effects of teleworking on the $CO_2$ emissions in ForFITS was possible through the modification of the parameters related to the annual average distance travelled by passenger vehicles used for personal transport. This approach was based on a the methodology employed in similar studies looking at the effect of different transport policies on the GHG emissions using ForFITS as a modelling tool (Esther Menezes et al., 2017). In this study, modelling of the effect of teleworking was based on two sets of data sources:

i) the percentage of jobs in Malta which can be home-based and do not necessitate the presence of the worker at the place of work; and

ii) the distribution of trips by type of activity at destination which data was collected during the travel survey in the first step of this backcasting study.

The first set of data was derived from a recent study on the potential for teleworking in Europe which looked into the percentage of occupations which can be performed from a home-based setting in different EU countries. The study, which was carried out following the growth of teleworking during Covid-19 crises, has estimated that in Malta the percentage of employees in occupations which can be performed through telework amounts to around 42% (Milasi et al., 2020). This value includes only employees and does not factor self-employed workers.

The travel survey carried out in the first stage of this research showed that 20% of reported activities at destination were work. Including all trips to and from work, 40% of all the trips in Malta are a result of commuting practices (Chapter 5, Section 5.2.3; Table 5.2). Based on this data, it was assumed that around 60% of all work-related trips can be reduced if teleworking facilities, as described by this scenario narrative, were to be implemented. The 60% shift reflects the study by Milasi et al., (2020) and an additional 17% shift would be possible due to improvement in ICT by the year 2050. This reduction in passenger kilometres was inputted into ForFITS to model the effect of teleworking as described in Table 7.6.

A similar approach was adopted when calculating the passenger kilometres that would be reduced if education was provided on-line. The travel survey carried out for the first phase of the backcasting process showed that travelling for educational purposes generated 13.2% of all the trips (Chapter 5, Section 5.2.3; Table 5.2). To model Scenario 2, a 50% reduction in these trips was assumed. Similarly, the same approach was used to model the effect of online shopping on the emissions from transport. Literature investigating the potential of online shopping as a means to reduce emissions from transport, have demonstrated that this form of retail activity has the ability to decrease the number of trips made for the purpose of buying objects. A shift to on-line shopping has the potential of reducing car trips and the related emissions in the range of 22% to 70% (Cairns, 2005; Carling et al., 2013; Rosqvist et al., 2016). For this study, a reduction of 60% of all trips made for shopping was assumed. These reductions in trips travelled as a result of teleworking, online education and online shopping were calculated and to reflect this change in ForFITS, the passenger kilometres in the model were reduced based on the percentage trip reduction.

This future scenario also describes a situation where the share of active modes of travel increases. In ForFITS, this was simulated by assuming a 10% increase in the kilometres for non-motorised transport in the base year. Scenario 2 also assumes the adoption of cleaner powertrain technology. As in the case of future transport Scenario 1, the shares of different powertrains were adjusted to simulate a shift to a higher share of electrically powered vehicles for personal travel. For this scenario, it was assumed that 40% of the light vehicles would be powered electrically.

**Table 7.5: Model input parameters for Alternative Transport Scenario 2**

| Scenario aspect | Description | Model Parameters |
|---|---|---|
| Less travel due to teleworking facilities and on-line education | An assumption was made that the use of teleworking and on-line education would reduce the number work and education related trips by half | The passenger kilometers for the base year were reduced based on the share of the number of trips for these activities |
| On-line shopping | On-line shopping would reduce the shopping related trips | |
| Changes to main powertrain | An assumption was made that under this scenario, 70% of the vehicles for personal transport would be electrically powered | The shares of the different powertrains in the transport system was changed to reflect a shift to electrical power |
| Increase in active travel | Under this scenario, active travel would increase by the year 2050 | Passenger kilometers for the base year for non-motorised transport were increased by 10% |

### 7.5.2 Modelling outputs for Alternative Transport Scenario 2

The results from the simulation for future transport Scenario 2 are summarized in Table 7.6. The table shows that in the target year 2050, the total tank to wheel emissions from road transport would amount to 130.1 kt$CO_2$e. These levels of GHG emissions are lower when compared to the BAU scenario, (Table 7.1) where the estimated emissions for the target year were at 556.7 kt$CO_2$e. Compared to the BAU scenario, alternative Scenario 2 would result in a 74.3% decrease in emissions in 2050. This decrease is largely due to the result of a reduction in the kilometres travelled expressed both as vehicle kilometres and passenger kilometres. The shift to electrically powered vehicles under this scenario also contributes to observed reduction in emissions.

**Table 7.6: Outputs for Alternative Scenario 2**

| Output Variable by Mode | Unit | Value |
|---|---|---|
| TTW emissions – Light Duty Vehicles (LDVs) | $ktCO_2e$ | 130.1 |
| TTW emissions – Two Wheelers | | 4.2 |
| TTW emissions – Large Road (including buses and coaches) | | 8.8 |
| Total TTW emissions | | 143.2 |
| | | |
| Activity Intensity - LDVs | vkm, billion | 2.8 |
| Activity Intensity – Two Wheelers | | 0.2 |
| Activity Intensity – Large Road | | 0.1 |
| | | |
| Passenger transport Activity Intensity (LDVs, Two Wheelers) | pkm, billion | 3.2 |

*Own elaborations based on:* International Monetary Fund, 2019; NSO 2009, 2014, 2019, 2020; European Commission Directorate Genral for Economic and Financial Affairs, 2018, UNECE Transport Division, 2014, Hass et al., 2014, European Environment Agency, 2019, Enerdata Research Service, 2018.

## 7.6 Alternative Future Scenario 3

The third alternative future transport scenario depicts a situation where the urban environment has been designed to allow for more active travel, the use of personal transport is discouraged by the introduction of taxes and congestion charging. In this scenario, the provision of public transport would have improved by the year 2050 to allow for the different practices such as shopping and commuting to work, to be made by means of this mode of travel. Furthermore, the public transport system in 2050 would be based on a fully electrical vehicle fleet (refer to Chapter 6, Section 6.2.5 for the full narrative).

### 7.6.1 Model Parameters

In alternative transport future Scenario 3, the urban environment has been re-designed to allow for more active travel. Modelling of the impacts of this scenario on emissions from transport required establishing the degree of shift from car-based travel to active forms of mobility that such a future would entail. Literature on transport research has demonstrated that policies that promote active travel can have a significant impact on the growth of these forms of mobility (Ogilvie et al., 2004). The average distance travelled by car in Malta is relatively short, with mean trip lengths during the morning peak being of 5.5km (Transport Malta, 2016a). This short distance provides ample opportunities for a shift to active modes of travel in particular cycling and travel with electric bicycles. Review of studies on the effects of interventions for the promotion of cycling and walking in different cities have shown that improvement of walking and cycling infrastructure have the potential of increasing the modal share of active travel (Lovelace et al., 2011). For the purpose of modelling emissions under alternative Scenario 3, it is assumed that there is a shift of 50% from car-based trips to walking and cycling. To represent this shift in the model, the passenger kilometres for light duty vehicles in the base year were reduced by 50% as described in Table 7.8.

This scenario also describes a future where the use of the private car has been greatly discouraged through the implementation of taxes (financial disincentives). ForFITS allows the input of parameters related to tax in the form of fuel tax, which parameters were used in the modelling of emissions under Scenario 3. Under the conditions stipulated by this scenario, a tax increase of 30% was assumed by the year 2050.

Changes to the public transport system described in future transport Scenario 3, were modelled by changes in two parameters of the model. First, the share of powertrains for the vehicles used for the public transport was changed from one which relied on internal combustion engines to one where the predominant form of energy is electrical. The improved public transport system would encourage modal shift from the private car to the public transport system. Similarly, to the case of future transport Scenario 1, this change was simulated through changes in the input parameter, passenger transport system index. A 10% increase in the public transport system index from base-year (2018) to target year (2050) was included with the changes in the modelling parameters (UN Economic Commission for Europe, 2016; UNECE, 2013; J Zawieska et al., 2018). In addition, during the simulation of this scenario, another parameter was also modified. ForFITS includes a parameter "environmental culture index" which allows an input range from 0 to 1, where zero represents a situation where there is no environmental culture and one a situation where the public is aware of the environmental effects of transport. For this scenario, the environmental culture index was increased to one by the year 2050 (J Zawieska et al., 2018).

**Table 7.6: Model input parameters for Transport Scenario 3**

| Scenario aspect | Description | Model parameters |
|---|---|---|
| Modal shift from light vehicles to active modes of travel | Urban design allows for more active travel. Short trips can be made by active modes of travel | The passenger kilometers for the base year were reduced based on the share of the number of short trips |

| | | |
|---|---|---|
| Introduction of taxes | Taxes that would discourage car use are part of the transport future Scenario 3 | Fuel taxes increased by 30% from base year |
| Changes to main powertrain for public transport system | An assumption was made that under this scenario, 80% of the vehicles for public transport would be powered electrically | The shares of the different powertrains in the transport system was changed to reflect a shift to electrical power |
| Improved public transport system | The public transport has improved under this scenario encouraging its use | A 10% increase in the passenger transport system index from base year |
| More environmental awareness | The public has more awareness on the environmental | Changes in environmental culture index from 0 to 1 |

### 7.6.2 Modelling outputs for Alternative Transport Scenario 1

The results of the modelling exercise carried out for future transport Scenario 3 are summarized in Table 7.7. The table shows that in the target year 2050, the total tank to wheel emissions from road transport would amount to 164.0 kt$CO_2$e. These levels of GHG emissions are lower when compared to the BAU scenario, (Table 7.1) where the estimated emissions for the target year were at 556.7 kt$CO_2$e. Compared to the BAU scenario, alternative scenario 3 would result in a 68.4% decrease in emissions in 2050. The results show that urban design and a shift to active modes of travel and away from the personal car has the potential of reducing the emissions from road transport. The provision of an improved public transport service, which is also based on electrical powered vehicles has an important impact on the levels of emissions from road transport.

**Table 7.7: Outputs for Alternative Scenario 3**

| Output Variable by Mode | Unit | Value |
|---|---|---|
| TTW emissions – Light Duty Vehicles (LDVs) | kt$CO_2$e | 164.0 |
| TTW emissions – Two Wheelers | | 3.7 |
| TTW emissions – Large Road (including buses and coaches) | | 8.3 |
| Total TTW emissions | | 176.0 |
| | | |
| Activity Intensity - LDVs | vkm, billion | 2.9 |
| Activity Intensity – Two Wheelers | | 0.1 |
| Activity Intensity – Large Road | | 0.2 |
| | | |
| Passenger transport Activity Intensity (LDVs, Two Wheelers) | pkm, billion | 3.5 |

## 7.7 Emission Reduction Potential for Alternative Scenarios

### 7.7.1 Performance of alternative futures

The preceding sections have presented the results of the modelling exercise which served to quantify the GHG emissions under different alternative transport future scenarios. Each of these scenarios describes futures where the mobility practices have changed and have been reconfigured in such a way that emissions from the sector are less than the BAU scenario. The results of the modelling exercise provide the basis for evaluating the potential of the alternative scenarios in meeting the climate change mitigation targets. This section will provide a comparative analysis of the three alternative scenarios relative to the BAU scenario and discuss the potential of each in reaching the emission reduction target. A summary of the results of the modelling exercise is presented in Table 7.8 and Figures 7.2.

**Table 7.8: Model outputs for different scenarios**

| **Output Variable** | **Unit** | **Scenario** | | | |
|---|---|---|---|---|---|
| | | **BAU** | **Future 1** | **Future 2** | **Future 3** |
| TTW emissions – Light Duty Vehicles (LDVs) | **$ktCO_2e$** | 512.5 | 335.1 | 130.1 | 164.0 |
| TTW emissions – Two Wheelers | | 8.6 | 5.6 | 4.2 | 3.7 |
| TTW emissions – Large Road (including buses and coaches) | | 35.6 | 15.5 | 8.8 | 8.3 |
| Total TTW emissions | | 556.7 | 356.2 | 143.2 | 176.0 |
| **Percentage Change from BAU** | | | -36.1 | -74.3 | -68.4 |
| | | | | | |
| Activity Intensity - LDVs | **vkm, billion** | 8.2 | 5.3 | 2.8 | 2.9 |
| Activity Intensity – Two Wheelers | | 0.3 | 0.2 | 0.2 | 0.1 |
| Activity Intensity – Large Road | | 0.2 | 0.15 | 0.1 | 0.2 |
| Passenger transport activity intensity (LDVs, Two Wheelers) | **pkm, billion** | 9.2 | 6.1 | 3.2 | 3.5 |

*Own elaborations based on:* International Monetary Fund, 2019; NSO 2009, 2014, 2019, 2020; European Commission Directorate Genral for Economic and Financial Affairs, 2018, UNECE Transport Division, 2014, Hass et al., 2014, European Environment Agency, 2019, Enerdata Research Service, 2018.

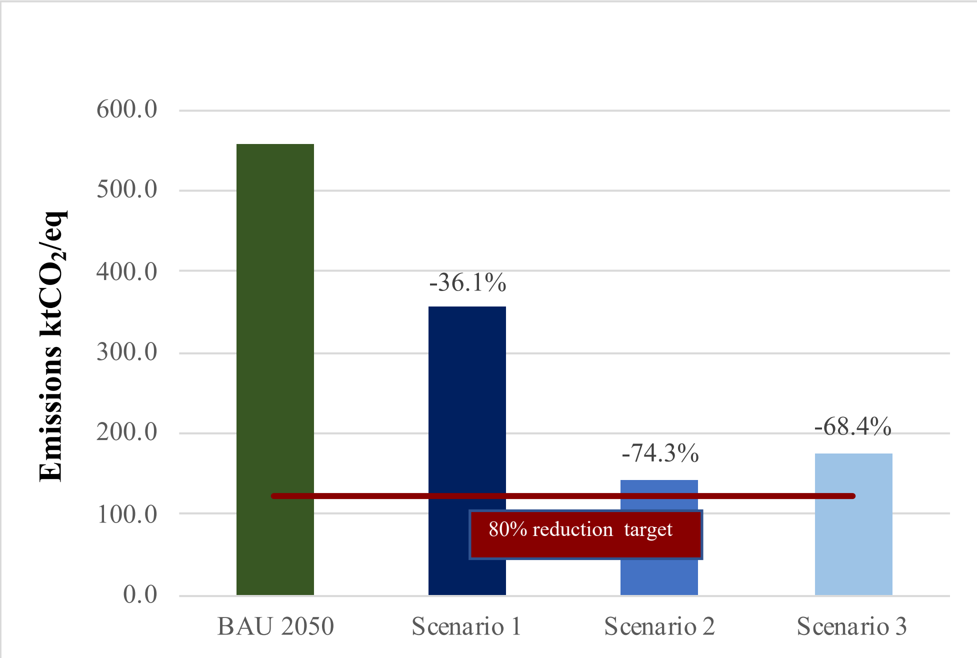



**Figure 7.2: GHG emissions under different future scenarios and as compared to the BAU**

The results presented in Table 7.8 show that in terms of total GHG emissions from road transport, alternative transport future Scenario 2, *Local Active Mobility,* presents the highest percentage decrease from the BAU conditions. Alternative Scenario 2 describes a future which focuses on a reduced need for travel through enhanced teleworking, online education, and online shopping. As observed from the temporary shift in travel behaviours due to the COVID-19 pandemic, increased teleworking and more localised travel could reduce $CO_2$ emissions from road transport more quickly (Bereitschaft et al., 2020; Nieuwenhuijsen, 2021). The results of the modelling exercise was useful to show how under the conditions described in alternative Scenario 2, $CO_2$ emissions could be reduced by around 74% from BAU levels. The level of emissions under Scenario 2 are significantly lower than the BAU scenario in 2050, however the level of reduction does not meet the desired target of 80% reduction from the current levels.

Future Scenario 3, *Green and active travel,* presents a lower emission reduction potential than Scenario 2 with around 68% reduction from the BAU (Table 7.8). The results in Table 7.8 are concordant with other studies which demonstrate how an urban design that would allow for more active travel and improved infrastructure for active modes of travel can effectively lower the $CO_2$ emissions from the transport sector (Brand et al., 2014; Brand et al., 2021; Winters et al., 2017). In agreement with other transport studies, measures that promote active transport together with an improved public transport system and policies which restrict car use have a good potential in reducing emissions (Brown et al., 2015; Nieuwenhuijsen et al., 2016).

Alternative transport Scenario 3 demonstrates a good potential for emission reduction however, it does not provide the required degree of change if the ambitious climate change mitigation target of 80% reduction from the current levels is to be achieved.

Contrastingly, *High Tech Mobility* (Scenario 1), illustrates a future with the least potential for emission reduction. This scenario describes a future with significant technological advancement together with an improved transport system. Model estimates show how under this scenario, the emissions could be reduced by 36% when compared to the BAU scenario. The results are in agreement with other studies which have demonstrated that technological change offers a good potential to reduce emissions from transport, yet technological innovation alone is not enough to bring about the required reduction in emissions (Andrejszki et al., 2014; J Zawieska et al., 2018). This potential is further enhanced when such measures are coupled with other changes in the transport system such as improvement in the provision of public transport (Marc Georges; Haddad et al., 2018). This scenario assumes vehicles are shared and based on clean electric energy. This future may be difficult to implement since electric cars are likely to be very expensive. Realisation of this scenario means there is the need for subsidies to make vehicles cheaper for all.

## 7.8 Conclusion

The modelling exercise proved a useful tool for the evaluation of the potential of the alternative future scenarios in achieving the desired emission reduction targets for Malta. The modelling exercise was important to show how the alternative transport future scenarios present a wide range of options for low-carbon futures and have different effects on the total emissions. Alternative transport Scenario 2, *Local Active Mobility*, shows highest percentage emission reduction from the baseline and thus offers the highest mitigation potential. In this scenario the emissions are significantly reduced through more localised mobility and reduction of car-based travel. Alternative transport future Scenario 3 - *Green and Active Travel,* has lower emission reduction potential than the alternative Scenario 2. In these scenario, prioritisation of active modes of travel are at the centre of the lower levels of $CO_2$. Implementation of these scenarios would require investment in ICT and infrastructure that facilitates active travel. Scenario 1, on the other hand is more difficult to implement since it most likely requires high investment and subsidies that would make electrical vehicles affordable.

The next chapter will focus on how the alternative future scenarios can be achieved. It describes how stakeholder engagement and public participation were key to develop policies and specific timelines that would allow a transition to more sustainable transport future.

# CHAPTER 8: TRANSITION TO SUSTAINABILITY

## 8.1 Introduction

This chapter presents the results of the last phase of the backcasting process, the transition phase. This phase of the framework aims to engage stakeholders in the design of policy interventions and implementation time-frames to achieve the alternative transport future visions developed during earlier phases of the research. It covers the third objective of the research and answers the fourth research question namely: *What policy implementation pathways can be developed to meet the sustainable mobility practices?*

The transition phase is a critical step of the backcasting exercise. In backcasting studies, this phase is rarely well developed, and usually done at the expert level (by the analyst), rather than including a participatory element. However, the implementation of policies and programming on interventions often becomes problematic due to objection and resistance from the public. A participatory approach to planning of policies and interventions helps to bridge this gap and facilitate the implementation of transport policies.

The chapter starts with a description of the results which emerged from the participatory approaches used during this phase. It provides details of the outcomes of the stakeholder survey, interviews with stakeholders and citizen workshop. In addition to presenting the results, the chapter also provides the details of the analysis which followed the data collection stages. These steps include the elaboration of the concepts developed during the surveys, the refinement of ideas generated from the interview transcripts and evaluation of citizens' responses and ideas to policy interventions. The Chapter then goes to explain the details of the final policy pathways which were designed during the transition phase. In addition to presenting the outcomes from the different stages, this chapter provides an opportunity to examine how the involvement of different stakeholders and the application of a practice-based approach shapes the design of policy interventions aimed at transitioning towards more sustainable transport futures.

## 8.2 Transitions to sustainable futures

The visions of alternative transport futures for Malta for 2050 developed during the visioning phase of the backcasting exercise (Chapter 6) were used as the starting point for the transition phase. The aim of the transition exercise was to design policy pathways which work towards the achievement of the alternative transport futures. The transition phase was based on a participatory approach which engaged a range of stakeholders and included the input of citizens in the design of policy interventions using the Theory of Social Practice as a guiding framework. This meant that through the process, the participants were guided to think in terms of which policies could reconfigure the elements of the current unsustainable mobility practices to more sustainable future practices or influence how other forms of social practices create demand for mobility. The engagement of different stakeholders necessitated the integration of several participatory tools which included surveys, interviews, and workshops. The process adopted for the transition phase of this backcasting study is presented in Figure 8.1

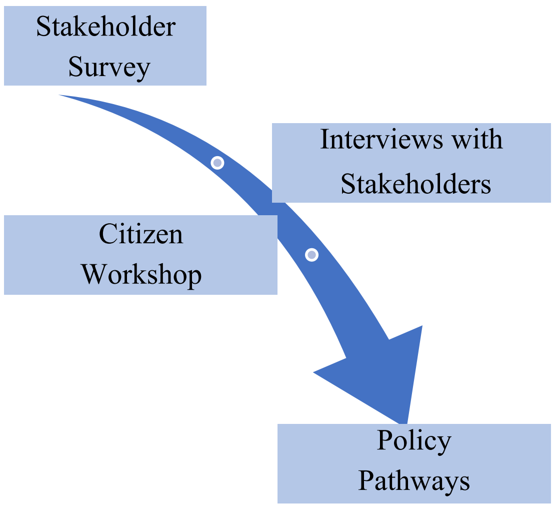



**Figure 8.1: Transition process**

During the participatory process of policy design, it was critical for the participants to have a clear understanding of the backcasting process, the alternative transport futures and the main concepts of the Theory of Social Practice. To facilitate the participatory process and enhance the effectiveness of the policy design, the narratives of the alternative transport visions described in Chapter 6, were first condensed to short narratives with an emphasis on the most critical changes in mobility practices that each of the future would entail. These narratives, which are found in Table 8.1, were used to guide the stakeholders during both the survey and the interviews. This exercise of summarising the scenario narratives, was also useful for the citizen workshop which was also part of the transition phase of the backcasting exercise. The main concepts of the narratives of the alternative futures were extracted and presented as a summary as shown in Figure 8.2.

**Table 8.1: Scenario narratives used during transition workshop**

| Scenario | Narrative |
|---|---|
| **Alternative Future 1:**<br><br>**High Tech Mobility** | It is the year 2050 and the demand for travel is still strong. Individuals have very **busy lifestyles** and are **moving fast** from one point to another. However, technology has evolved in such a way as to allow for an easy **transition from private car to mass transit travel.**<br><br>A new form of transport system characterises the mass transport system. A **high-density network of transport capsule lines** allows very fast movement of people from one place to another. The system, which is powered by **clean energy**, is designed is such a way as to allow for easy interchanges between other modes of transport. **Bicycle sharing facilities** are available close to the stops of the capsule lines and bicycles can be transported inside the capsules. A **fully electrical bus fleet** with segregated lanes provides quality transport for the bulk of mobility needs.<br><br>In this scenario, individuals make use of **connected and autonomous vehicles** (CAVS) and conventional cars for personal mobility. CAVS allow easy sharing of trips which also serves as a means of social integration where individuals are no longer isolated within their personal car but can socialise during their day-to-day travel. Private cars, on the other hand, run on **new fuels** with low carbon emissions. |
| **Alternative Future 2:**<br><br>**Local Mobility** | It is the year 2050 and the use of technology is focused on enabling lifestyles with high **mobility at the local scale** through forms of active travel. Individuals are mobile, however now they are traveling more locally over shorter distances.<br><br>An **efficient IT infrastructure** now permits businesses to shift part of their operations to remote working. Universities and high-level education institutions have integrated **e-learning** as part of their methods for education. Local centres compliment the e-learning facilities. These centres provide a space where students can utilise facilities and interact with other students.<br><br>**Electric scooters and travel escalators** help individuals to travel over short distances. People have learnt that the car is no longer a sign of status. **Shopping for goods over the internet** is largely promoted and helps reduce the number of trips to large supermarkets. Goods are delivered to homes via clean transport modes. Travel for other activities such as childcare and social activities can take place through electric vehicles managed centrally or through **Mobility As A Service (MAAS)** services which are regulated. Private cars are electric and are used for long distance travel.<br><br>Travel over longer distances is facilitated by **a dense network of public transport**. Educational programmes aimed at improving IT skills have facilitated the use of **mobile applications** for public transport. Individuals can plan the best route and have information in real-time on the location of the bus, so that they can plan their journey more effectively. |

**Table 8.1: (Continued) Scenario narratives used during transition workshop**

| | |
|---|---|
| **Alternative Future 3:**<br><br>**Green and Active Mobility** | It is the year 2050 and an **improved urban design** that prioritises active travel over other forms of transport. A **network of interconnected greenspaces** with paths which are wide, safe and free from obstructions facilitates active travel such as walking.<br><br>The urban community is aware about **the health benefits of active travel** over other modes of transport. **Tax benefits** are in place for those who chose to travel using active modes of travel including walking and the (electric) bicycle. **Low-emission zones and parking taxes** mean that the use of cars is greatly discouraged. Signs along walking paths which show actual distances between localities provide pedestrians with the knowledge about the actual distances and the best route they need to take.<br><br>**Buses are available at the periphery** of this new urban plan and they run on separate lanes than those used for walking or cycling. Buses connect towns together allowing for travel over longer distances. A dense network of public transport provision means that the **buses run on time and are frequent and can compete with the efficiency offered by the car.** Inside the towns, **electric shuttles** are available, and these are connected to the bus system. This system of shuttles allows for people to carry out other activities such as social activities, carrying of goods from food stores and other work-related activities. |

| Vision 1: High Tech Mobility | Vision 2: Local Mobility | Vision 3: Green and Active Mobility |
|---|---|---|
| High demand for travel | High mobility at the local scale through forms of active travel | An improved urban design that prioritises active travel |
| Technology driven | Individuals are still mobile, however now they are traveling more locally over shorter distances | A network of interconnected greenspaces with paths which are wide, safe and free from obstructions |
| Transition from car to mass transit | An efficient IT permits remote working | Tax benefits are in place for active modes of travel |
| High density network of transport capsule lines | On-demand shared transport for travel to work | Low-emission zones and parking taxes |
| Interchanges between other modes of transport | E-learning at high-level education institutions with local centers which compliment the e-learning facilities | Wayfinding system with actual distances |
| Fully electrical bus fleet with segregated lanes | Electric scooters and travel escalators | Buses are available at the periphery |
| Connected and autonomous vehicles (CAVS) | On-line shopping for goods | Autonomous electric shuttle inside the towns |
| New fuels with low carbon emissions | Mobility As A Service (MAAS) | |
| | A dense network of public transport | |
| | Mobile applications facilitate public transport use | |

**Figure 8.2: Summary of future scenarios used during citizen workshop**

## 8.3 Stakeholders' proposals for policy interventions

### 8.3.1 Identification of policy measures

The first step of the transition phase of the backcasting process was based on a survey methodology that engaged stakeholders in the design of policy packages which could contribute to the alternative transport futures developed in the previous phase of the process. The use of integrated policy packages as opposed to single measures is known to be more effective to achieve desired transport futures (Hickman et al., 2012). The first step in designing policy packages involved identifying policy measures that can be integrated into supportive and more effective policy packages. A desk-exercise by the researcher identified a list of policies which served as the basis for the stakeholder survey and policy packaging. As detailed in the methodology Chapter 4 (Section 4.8.1), the identification of policy measures was based on a review of academic articles, policy documents and other literature from transport practices. This exercise yielded a list of 101 policy options and are summarised in Table 8.2 with different policy groups and examples for each group (for a full list of policy options refer to the Appendix G).

**Table 8.2: Individual policy measures**

| Policy Group | Examples |
|---|---|
| New technology and greener fuels | Investment in development of cleaner fuels<br>Subsidies for the purchase of electric vehicles |
| Improved public transport network | More frequent buses<br>Decreased public transport fees |
| Policies that encourage modal shift | Cycle and pedestrian routes<br>Flexible working hours |
| Pricing polices | Tax on fossil fuels<br>Parking and road use pricing |
| Awareness raising polices | Individual travel planning<br>Awareness raising campaigns on the benefits of active travel |
| Land use and spatial development | Strategic planning integrating land use and transport<br>Urban planning that reduces travel distances |
| Restricted access to vehicles | Limited access to vehicles in urban centres<br>Parking controls |
| Promotion of multi-modal travel | Integrated ticketing system for multi-modal use<br>Bicycle sharing stations close to bus stations |
| Infrastructural improvements | Improved walking and cycling infrastructure<br>Better infrastructure for electrical vehicle charging |

*Source: compiled by author from Berkhout et al. (2015); Deetman et al. (2013); Dugan et al. (2022); Gross et al. (2009); Hrelja et al. (2022); Huber et al. (2021); Santos et al. (2010); Thaller et al. (2021)*

### 8.3.2 Policy packaging

Through a survey, the stakeholders were guided to cluster the policy measures into different policy packages for each of three alternative transport futures as described in the methodology Chapter 4 (Section 4.8.1). The survey results were analysed and common patterns in the clustering of individual policies into packages were identified. The responses from the survey showed that was a general agreement between the stakeholders on which type of policies would likely contribute to achieve the desired transport futures. For example, when designing policy packages for alternative transport vision 1 – *High Tech Mobility*, stakeholders showed preferences towards policies which promote the use of cleaner fuels and those that disincentivise use of conventional vehicle technology. Supporting policies, such as the promotion of public transport use were also identified as important measures to achieve the first of the alternative transport futures. Policies such as the introduction of tax on fossil fuels, investment in public transport and regulations which facilitate the introduction of cleaner powertrains received high number of scores during the policy packaging exercise. A process of finding commonalities between inputs from the stakeholders resulted the identification of a set of policy packages for alternative transport vision 1 (*High Tech Mobility*) which is summarised in Table 8.3.

The policy packages for alternative transport future 1 present a set of measures which aim to decrease emissions from transport sector by reducing the reliance on private car use and conventional fuels. The policy packages also recognise the importance that for transitions from of providing alternatives to car use and include measures which aim to implement a strong investment in public transport and promote the use of this mode of mobility. Other policy packages (policy package 4) include policies which promote the use of cycling as a means of transport and multimodal mobility.

**Table 8.3: Policy packages for *High Tech Mobility* transport vision**

| | |
|---|---|
| **Policy Package 1** | Tax increase on fossil fuels<br>Investment in new mass transit system<br>Introduction of new fuels<br>Public transport fare structures such as flat rates, zonal fares and monthly passes<br>Vehicle ownership restrictions (e.g. 1 per family) to promote car sharing |
| **Policy Package 2** | Measure to improve vehicle emission standards<br>License fee based on fuel efficiency<br>Introduction of smart vehicles<br>Incentives to those using cleaner fuels or using public transport |
| **Policy Package 3** | Introduction of new fuels<br>Regulations targeted at improving efficiency of conventional vehicles<br>Mandatory regulations for the introduction of electric vehicles<br>Tax increase on fossil fuels<br>Measure to improve vehicle emission standards |
| **Policy Package 4** | Increased network of bike sharing<br>Integrated ticket system for bus, mass transit and shared bicycle facilities<br>New modified bus service<br>Incentives to those using the bus e.g. discounts |
| **Policy Package 5** | National road pricing<br>Parking Pricing<br>License fee based on fuel efficiency<br>Investment in new mass transit system |

The same process of seeking common patterns in policy packages designed by stakeholders was carried out for all three alternative transport visions. Table 8.4 provides a summary of the policy packages for alternative transport vision 2 – *Local Active Mobility.* The set of policy packages designed for the second alternative 2050 transport vision are distinctively different from those which the stakeholders planned for the first transport vision. The policy packages for alternative transport future 2, show a strong focus on the shift from car-based travel to active modes of mobility. The uptake of electrical vehicles, increased public transport use and reduction in travel distances are also at the focus of policy packages which the stakeholders think are appropriate for achieving the second alternative transport vision. Table 8.3 shows how the stakeholders designed policy packages which go beyond the transport sector and include policies which target changes in other spheres of social life including work and education.

**Table 8.4: Policy packages for *Local active mobility* transport vision**

| | |
|---|---|
| **Policy Package 1** | Subsidies and incentives for purchase of electric cars<br>Incentives to promote hybrid and electric cars for urban delivery |
| **Policy Package 2** | Marketing campaigns to promote active travel based on experience of users<br>Information on walking routes<br>Wayfinding system to encourage walking<br>Individualised travel planning |
| **Policy Package 3** | Route planner for cyclists<br>Information on cycle routes<br>Showering facilities at workplace to encourage people walking to work<br>incentives to those using bikes |
| **Policy Package 4** | Integrated ticket system for different modes<br>Safe routes to school<br>Wider and better maintained cleaner pavements<br>Location of bus stops close to employment centres |
| **Policy Package 5** | Trip planning systems which provide information on alternatives before start of the journey<br>New and modified bus service<br>Provision of real-time information about the bus<br>Investment in demand responsive transport |
| **Policy Package 6** | Incentives to promote teleworking<br>Promotion of flexible working hours<br>Flexible work start times for low-carbon commuters<br>Mandatory green travel plans for new developments |

The results of the stakeholder survey also produced a set of policy packages for the third alternative transport future which are summarised in Table 8.5. The results provide a mix of policy packages which focus on restricting car-based travel while at the same time promoting actives forms of travel. Policies which include land use planning that reduce travel distances and facilitate active travel modes are part of one of the policy packages that the stakeholders think would achieve the alternative transport future 3. These policies where integrated with other supporting policies such as marketing campaigns to promote active forms of travel and cycling facilities at the workplace.

**Table 8.5: Policy packages for *Green active travel* transport vision**

| | |
|---|---|
| **Policy Package 1** | Investment in road infrastructure<br>Provision of bus to retail<br>Bicycle racks at bus terminals<br>Information on cycle routes<br>Increased network of bike sharing<br>Emphasis on vulnerable road users in license exams<br>Lower speed limits<br>Trip planning systems which provide information on alternatives |
| **Policy Package 2** | Wayfinding system to encourage walking<br>Integrated ticket system for different modes<br>Bicycle repair workshop<br>Information on cycle routes<br>Information on walking routes |
| **Policy Package 3** | Tax increase on fossil fuel<br>Vehicle ownership tax<br>Parking pricing<br>Parking controls including controls on duration, entry times and designated users<br>Taxation on imported used cars<br>Prioritising public transport, using bus lanes, BRTs |
| **Policy Package 4** | Strategic planning model to integrate land use, housing and transport<br>Land use development mix in which homes, jobs and shops are placed close together<br>Marketing campaigns to promote active travel based on experience of users<br>Integrated ticket system for different modes<br>Mandate of obligatory shower and locker facilities at work place |

## 8.4 Refinement of preliminary policy packages

### 8.4.1 Interviews with stakeholders

The second step in the transition phase of the backcasting process involved the refinement and elaboration of the initial policy packages. The second stage involved of interviews with stakeholders aimed to refine the list of policy packages and define policy pathways to reach the alternative 2050 transport futures. Interviews have been shown to provide a useful tool for engaging stakeholders in policy packaging and the transition phase of backcasting studies (VAWJ Marchau et al., 2003; Zimmermann et al., 2012a).

The detailed methodology was presented in Chapter 4 (Section 4.8.1). This involved the selection of a group of stakeholders including transport and urban planners, policy makers and NGOs who have an interest and expertise in sustainable transport. As described in Chapter 4, the stakeholders were selected to represent those groups of stakeholders which were involved in the visioning workshop but did not participate in the transition phase of the backcasting exercise. During the interviews, the researcher guided the participants to think ways in which policies can be further combined to increase their effectiveness, acceptability and feasibility. Interviewees were asked to define the time-scale for implementation namely short-term; medium term and long-term. Finally, the interviews concluded by asking the interviewees to discuss the key actors that are most suited for implementation of the policy pathways.

The interviews were audio-recorded and transcribed. The transcriptions were then subject to qualitative analysis. The process of qualitative analysis involved identification of themes and within the transcripts using an inductive approach. The main factors used during the coding exercise included the policy measures and implementation time-frames. The themes and codes were then re-worked and refined to identify the policy options which the interviewees in their discourse defined as appropriate for delivering the alternative transport futures. The results of the qualitative analysis are represented in Table 8.6

**Table 8.6: Qualitative analysis of interviews data for the transition phase**

| | Short-Term | Medium-Term | Long-Term |
|---|---|---|---|
| **Alternative Transport Future 1** | - Bus rapid transit can be a short term option which can be upgraded to a better system in the future (E1)<br>- Bus routes should be designed such as that they reach employment nodes (E1)<br>- Information on the true cost of car ownership and usage can make individuals aware of the cost (E1)<br>- Parking should become managed and made at a cost especially in town centres where there is congestion (E1)<br>- Parking should be made at a cost (E1)<br>- Marketing campaign and educational campaign on bicycle use (E2)<br>- Tax credits for bicycle use (E2)<br>- Start planning for mass-transit system (E2)<br>- Planning for a mass transport system should start in the short term (E3)<br>- Improving the efficiency of the public transport system, making it more flexible and improving the interconnections with other modes of transport (E3)<br>- Improvement of infrastructure making it easier for people to walk, cycle or use the scooter (E3)<br>- Encouraging people to walk and cycle by placing wayfinding signs(E3)<br>- mobile apps which can provide information on the best route(E3) | - The infrastructure for the autonomous car system requires medium to long-term planning (E1)<br>- Preparation of the infrastructure that would allow for autonomous vehicles (E2)<br>- Awareness campaigns about the effects of car use on emissions (E1)<br>- End of journey cycling facilities such as lockers, bike racks, showers (E1)<br>- Public transport infrastructure should be planned ahead of major projects such as business centre (E1)<br>- Autonomous vehicles, in the form of buses, can help to extend and improve the public transport system by improving frequency (E3) | - Planning and building of the mass transport system should continue in the long-term (E1)<br>- The mass transport system, for which planning started in the short-term, is completed by the 2050 target year (E2)<br>- Continued improvement in public transport (E3) |

**Legend**
E1: Expert 1 – Transport Planner
E2: Expert 2 – Policy Maker
E3: Expert 3 – Transport Planner 2
E4: Expert 4 – NGO (Bicycle Advocacy Group)

**Table 8.6 (continued): Results of the qualitative analysis of the interviews with stakeholders during the transition phase**

| | Short-Term | Medium-Term | Long-Term |
|---|---|---|---|
| **Alternative Transport Future 2** | - Investment in a good IT infrastructure. (E1)<br>- Investment in an infrastructure that allows for online shopping (E1)<br>- Use of public schools building for activities outside school hours (E1)<br>- commitment by the government, um, starting in the short and medium term to create more local services around most of the towns in Malta (E4)<br>- Small changes to our infrastructure to start getting more people out of their cars and into active transport (E4)<br>- Education campaigns and promotion of active modes of travel (E3) | - Enhance the electrical supply system to ensure all areas receive a good service (E1)<br>- Forward planning for all service providers such as electricity and telecommunication (E1)<br>- Development such as supermarkets are within the town centers and not the periphery of towns to allow to be accessed on foot (E1)<br>- On-line services made more feasible making it easier for people not to commute (E4)<br>- Promotion of mixed land uses including housing, business centers and, other supply chains, like supermarkets, so that these are closely knit together (E4)<br>- More holistic planning (E3)<br>- Financial incentives for companies to invest in teleworking (E3)<br>- Facilities, like shops and gyms close to the working place (E3)<br>- Discourage development of supermarkets at the edge of towns (E3)<br>- Development of public transport corridors (E3) | - Mixed use planning to limit the need to travel over long distances (E1)<br>- Co-working spaces, which companies can rent for their employees who live in that area (E3)<br>- Forward planning by the national government which integrates land use and transport (E3) |

**Legend**
E1: Expert 1 – Transport Planner
E2: Expert 2 – Policy Maker
E3: Expert 3 – Transport Planner 2
E4: Expert 4 – NGO (Bicycle Advocacy Group)

**Table 8.6 (continued): Results of the qualitative analysis of the interviews with stakeholders during the transition phase**

| | Short-Term | Medium-Term | Long-Term |
|---|---|---|---|
| **Alternative Transport Future 3** | - Short term can include walking paths and signs that enhance the legibility of the local towns (E1)<br>- Limit the developments to small scale rather than large developments to allow for permeability of the towns (E1)<br>- Communication with local councils to design more efficient bus routes (E2)<br>- Implementation of improved bus system (E2)<br>- Planning to make the bus efficient (E2)<br>- Heavy Subsidies for electric bikes (E2)<br>- Improve cycling infrastructure especially for new major road projects (E3)<br>- Incentives for cycling facilities at the work place (E2)<br>- Educational campaign, marketing and incentives (E2)<br>- Design of a proper walking and cycling network which can be upgraded in the long-term (E4)<br>- Introduction of parking meters to discourage car use (E4)<br>- The inclusion of low emission zones (E4)<br>- Other tax measures and tax incentives obviously can be laid down in the short term to start to encourage active travel (E4)<br>- Bikeability courses promoted along the islands across a more larger population and offered for free to the public (E4)<br>- Link promotion of active transport with other health targets such as reduction of obesity (E4)<br>- A quick fix within the short-term is the provision of more buses (E4) | - Long-term cycling policy and other policies that discourage car use (E1)<br>- Development such as supermarkets are within the town centers and not the periphery of towns and can accessed on foot (E1)<br>- Mixed use planning to limit the need to travel over long distances (E1)<br>- Longer term planning for transport beyond the 5-year election system (E2)<br>- Circular transport in localities for the elderly to make towns more accessible to these persons (E2)<br>- Limited access to vehicles in town centres (E2)<br>- Limit the number of parking spaces in town centres (E2)<br>- Promotion of cycling as a fast mode of travelling (E4)<br>- Further improvement in walking and cycling infrastructure (E3)<br>- Limit access to cars and give space to use by the people (E3)<br>- Planning of actual cycling routes that allow access to facilities including shops, places of worship and residential areas, especially higher density residential areas (E3)<br>- Create wayfinding signs to facilitate uptake of walking and cycling (E3)<br>- Designing a cycling plan that is followed through in the long-term (E4)<br>- Implementation of certain cycle and walking routes (E4)<br>- Closing of town centres for vehicular traffic (E4) | - Further investment in bus system (E1)<br>- Further improvements in walking and cycling infrastructure(E3)<br>- Continuation and updating of the walking and cycling network (E4) |

**Legend**
E1: Expert 1 – Transport Planner
E2: Expert 2 – Policy Maker
E3: Expert 3 – Transport Planner 2
E4: Expert 4 – NGO (Bicycle Advocacy Group)

### 8.4.2 Achieving the 2050 alternative transport visions

The interviews were useful to reveal a set of distinct ideas about what policies and policy pathways can contribute to the achievement of the alternative transport futures. During the discussions with the stakeholders on the achievement of alternative transport future 1 – *High Tech Mobility* – a high degree of consensus between interview participants emerged. Through their discourse stakeholders agreed that the achievement of the first alternative transport future requires significant investment in mass transit infrastructure. Policy pathways for this alternative future would necessitate stepwise planning which starts with short-term changes to longer-term investments. The stakeholders discussed how in the short-term, measures should be focused on the improvement of the current public transport system, which could be further upgraded to a better system in the future. A bus rapid transit system can provide one of the options in the short term. Short-to-medium term planning must also focus on the uptake of e-vehicles and educational campaigns for bicycle use. The stakeholders also pointed out that medium-term measures should start looking at the introduction of smart and autonomous vehicles. Long-term plans on the other hand would need to consider the planning of a larger system for mass transit which in the alternative future narrative is described as an underground system. Given the scale of such a project, the stakeholders agree and emphasise the importance of such planning starting in the short-term and continuing in the long-term. The effectiveness of these measures can be further enhanced by supplementary measures which promote public transport use including awareness campaigns, parking pricing and traffic management systems.

Alternative future 2 – *Local Active Mobility* – was the preferred alternative future amongst the interviewees. During the interviews, the stakeholders discussed how this type of alternative future can be well-suited to reduce emissions from transport. Throughout the interviews, it became evident that in the stakeholders' view this alternative future is more advantageous then the first transport future as it requires less investments in infrastructure. From the stakeholders' perspective, the changes required for the achievement of alternative future 2 are more feasible and easier to be implemented than those suggested in the first alternative future. The coding exercise following the transcription of the interviews revealed how *Local Active Travel* future requires policies that would see the investment in a good IT infrastructure, forward planning for all services such as electricity and telecommunication which ensure that all areas are well-supplied with the necessarily provisions that would allow teleworking and e-learning. Further policy measures should focus on improved urban planning with developments such as supermarkets being set-up within the town-centres rather than at the periphery of towns to allow easy access on foot. Policy options for mixed land use planning also provide a great potential to reduce the need to travel over long distances and contribute to the achievement of the second alternative transport future.

The qualitative analysis of the interviews was also important to explore the stakeholders' views on which policy pathways can deliver alternative transport future 3 – *Green and Active Travel*. The interviewees discussed how short-term plans should be focused on improving the walking infrastructure and signs which enhance the legibility of the local towns. Short-term measures would need to include those that improve the current public transport system. Complementing these measures, the stakeholders believe that the achievement of the third alternative transport future needs short-term measures which prioritise cycling. These would include improved cycling infrastructure, better road enforcement and limiting access to vehicles inside town centres.

The interview data revealed how medium-term transport policies for *Green and Active Travel* would necessitate urban planning which prioritises small scale developments which are accessible on foot from the town centre. Infrastructure for walking and cycling is further improved in the medium-term together with wayfinding systems and other policies that promote active forms of travel. During the interviews, the experts suggested how the medium-term policies should include measures that limit access to vehicles in town centres, whilst prioritising walking. Long-term measures for alternative future transport 3, would consist of measures that further develop the walking and cycling infrastructure and improve the public transport network.

### 8.4.3 Policy pathways for alternative transport visions

The results from the qualitative analysis of the interview data was used by the researcher to construct policy pathways for the alternative transport futures. This stage of the backcasting process produce three initial policy pathways which describe policies and implementation time-frames for the three alternative transport futures. These initial policy pathways are presented in Figure 8.3 which depicts a set of policies and their implementation time-frame (short-term, medium-term or long-term). The policy pathways present different sets of measures and supplementary measures which hope to deliver the alternative transport future.

They were designed based on a Theory of Social Practice approach and include policies which target different elements of the mobility practices. In this context, the measures were designed to bring about the necessarily changes not only in infrastructure. Policies were also set up to ensure that the necessarily skills are available to allow uptake of more sustainable mobility practices. Other policies, such as awareness campaigns, were aimed to change the meanings around practices to allow easy transition to the alternative transport futures. The influence of the Theory of Social Practice on the policy design process can be observed through those policies which target non-transport areas to bring about a shift to more sustainable mobility. For example, the resultant policy pathways include measures which aim to influence how people work, do their shopping or study to change the way in which they travel. This is different to contemporary transport planning approaches where the focus is most often on policies with direct implications for travel.

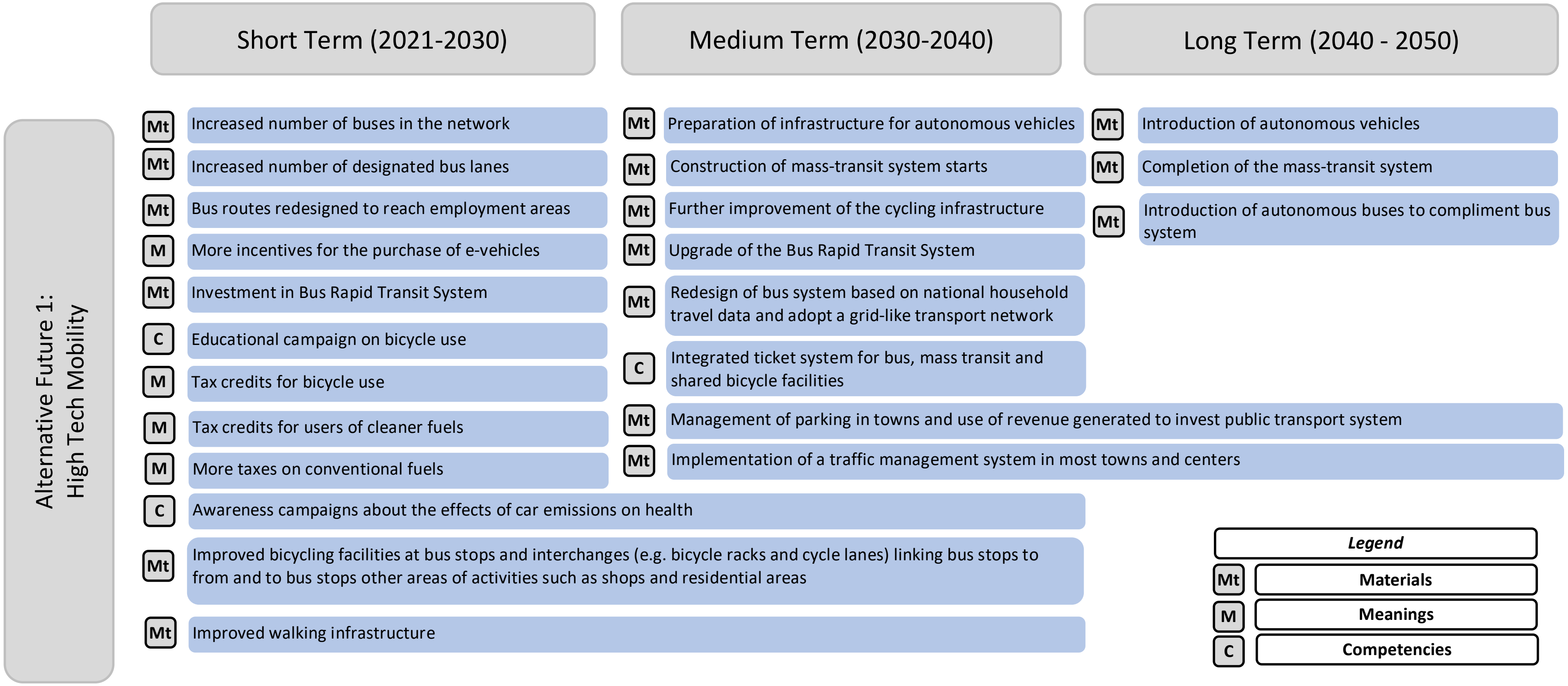



**Figure 8.3a: Policy pathways for alternative transport future 1**

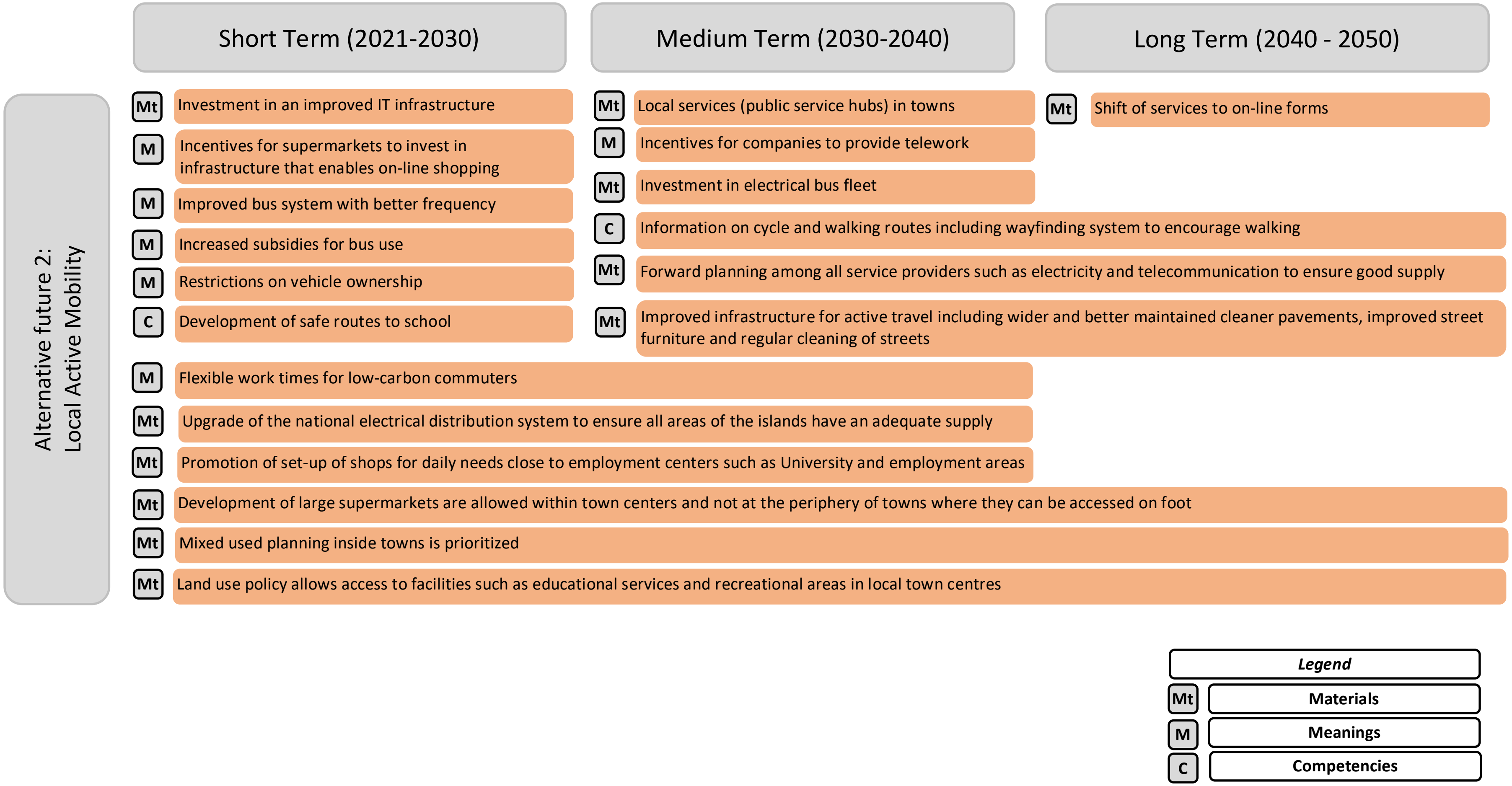



**Figure 8.3b: Policy pathways for alternative transport future 2**

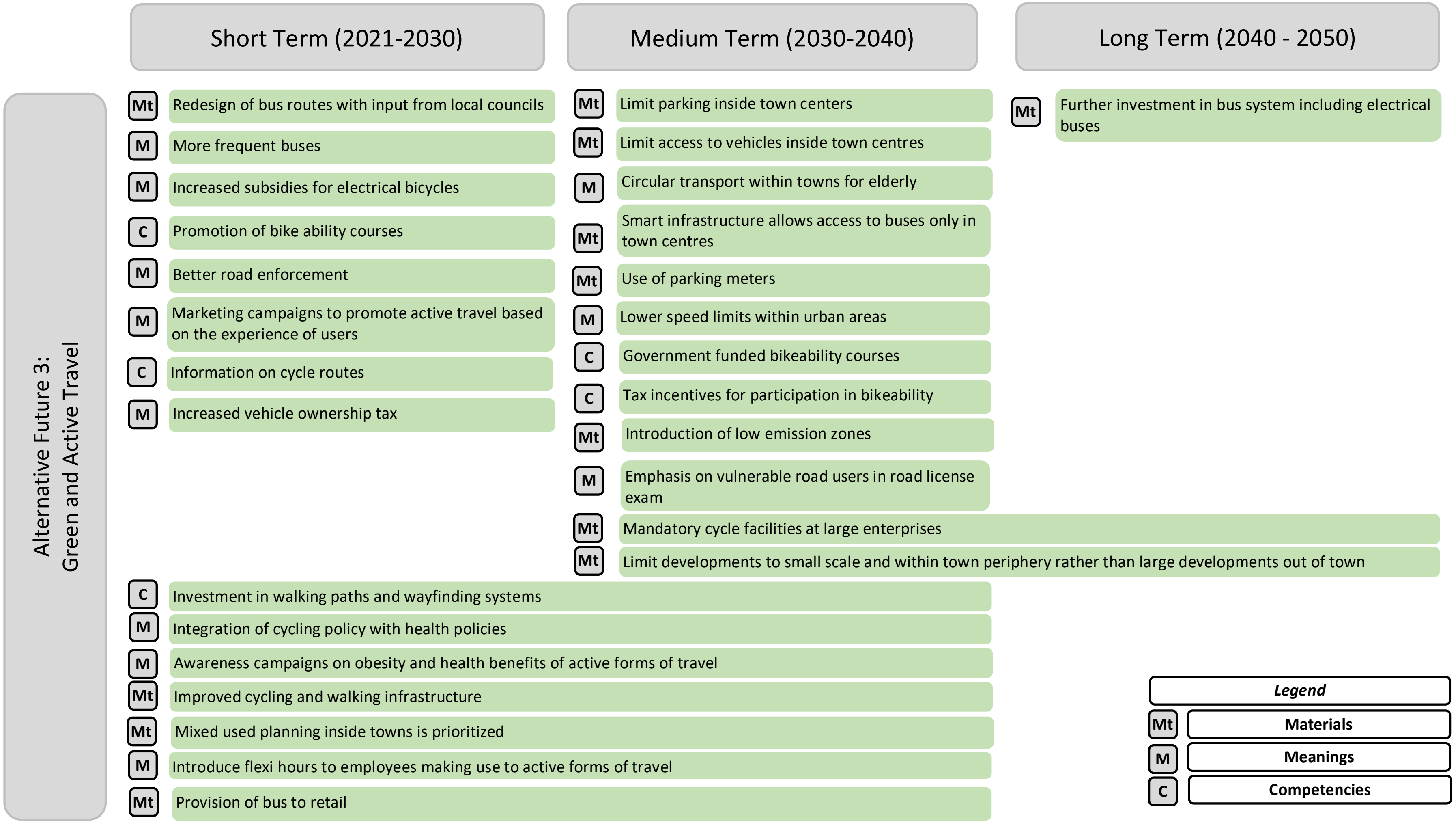



**Figure 8.3c: Policy pathways for alternative transport future 3**

The *High Tech Mobility* future would require improvement of the public transport system in the short-term together with measures that discourage car use. These can be supplemented by policies which promote cycling as a means of travel. In the medium-term, the stakeholders propose further improvement in the public transport system and cycling infrastructure together with measures that manage vehicle access and parking in town centres. The construction of the large mass-transit which would characterise the transport system in 2050 will start in the medium-term and continue in the long-term. The medium-term pathways would include the infrastructural planning for the introduction of autonomous vehicles. Long-term policy pathways would see the introduction of autonomous vehicles and the completion of the mass-transit system. The *High Tech Mobility* alternative future is a strong technology-based future with most of the policies aimed at technological transitions.

Policy pathway for *High Tech Mobility* future may be difficult to implement and a number of barriers may be encountered in achieving this alternative future. Decarbonisation of transport through electrification and introduction of CAVs face several technical issues. Implementation may be difficult since this scenario requires a large investment in terms of the supporting infrastructure (materials). Problems related to traffic congestion, road-safety, inequality in road space allocation would still persist when shifting to electrically powered vehicles. Besides the material elements, introduction of electrical vehicles and CAVs, faces also acceptability issues (e.g. in the way vehicles are used and enforcement of vehicle use), economic issues (cost of electrical vehicles) and social equity issues (e.g accessibility to new technology). These barriers would need effective polices which target the meanings around use of electrical vehicles and CAVs and which are often difficult to change. Problems may also arise in the shift from conventional vehicles to CAVs as a result of the way the vehicles are used on shared basis, road usage and pedestrian behaviour. Policy measures which target the competencies of road users are required for the implementation of this alternative future.

The policy pathways for the *Local Active Mobility* future presents a different set of measures from those for the first alternative future. As in the case of the first alternative transport future, the stakeholders believe that short-term measures require improvement in the public transport system. These will need to be complimented with measures that ensure a good IT infrastructure and policies that disincentivize car use. Measures which introduce flexible working hours and provide a good network of services would start in the short-term and continue into the medium term. The stakeholders envisage that achievement of the second alternative future require policies that target urban planning and land use development. These policies should start in the short-term and continue through the medium-term and the long-term. Medium-term policies need to focus on the provision of local services in towns, enhance teleworking and invest in improved public transport and cycle and walking facilities. Additional long-term planning will involve further shift of services and operations to on-line forms.

Some barriers can be foreseen for the implementation of the *Local Active Mobility* scenario. This future requires the shift to activities to the local scale, which need investment in infrastructure and urban planning to bring different activities closer to where individuals live and work (materials). The implementation of this future may also find resistance from the public who can find the lack of interaction with other individuals difficult to adapt to (meanings). In addition, individuals need to re-learn how to navigate from different sites using active modes of transport and adapt to changes in the way some social activities are performed (competencies). Changes in the ways individuals work or go to school may find opposition from the public.

Policy pathways for the third alternative transport future – *Green active travel* – show similarities with those for the second future. Short-term policies for this future would be focused on the redesign of the public transport system and promotion of active travel modes. Policies targeting active travel will continue in the medium term. Additional medium-term policies which would allow achievement of alternative transport future 3 would include those targeted at limiting the access to vehicles within town-centres and at the same time facilitate travel by foot and bicycle. Urban planning that reduces the need to travel over long distances hence facilitating active mobility needs to start in the medium term and continue in the long term. Additional long-term policies would then look at further infrastructural improvement in public transport.

Some difficulties may also be pointed out for the implementation of the third alternative future, *Green active travel.* For this scenario, a large transition is needed form car-oriented road infrastructure to high quality public transport and improved cycling and walking networks (materials). This shift may bring about may objections from the public who are used to the comfort and convenience of the car (meanings). Barriers to implementability of this scenario may arise to the lack of knowledge and skills about cycling or navigating from site to site using the network of walking paths (competencies).

### 8.4.4 Responsibility for Transition towards Sustainable Transport Futures

One of the aspects discussed during the interviews with stakeholders included the responsibility for the implementation of the policy pathways for the achievement of the alternative transport futures. Identifying the key actors for transport policy is a critical aspect for effective policy implementation. Determination of the level of responsibility for different institutions has been given significant importance in backcasting studies (Julio Soria-Lara et al., 2018; Tuominen et al., 2014).

The identification of key actors for policy implementation was explored through discussions with the stakeholder participating in the transition phase of the backcasting study. The researcher probed the interviewees to think about which institutions should take responsibility for initiating the changes and oversee the implementation of transport policies which lead to sustainable futures. This question raised discussions about the institutional levels at which changes towards sustainable transport should be initiated and who are the key stakeholders that should be involved in the implementation.

The interview data revealed that there was a general agreement between the stakeholders that the main responsibility for implementation of sustainable transport policy should start at government level. However, whilst national government should initiate the change and take the lead in the transition towards sustainable transport futures, other important institutions and key actors are to be involved in the process. Local government, for example, should also have a role in the transport policy process. The stakeholders discussed how local government play an important role when it comes to the design of local plans and planning for the design of public transport network. The interviewees also agreed that citizens should be involved in the policy design and implementation process.

These results are similar to those in other transport participatory backcasting studies which concluded that in the transition towards sustainable transport, the national government should take responsibility for the implementation of transport policies. Regional or local institutions should also take responsibility for the implementation of policies which target emission reduction from the transport sector. Citizens would be instrumental for the implementation of policies such as those which aim to raise public awareness on alternative transport and the use of ICT (Julio Soria-Lara et al., 2018; Tuominen et al., 2014).

This idea of having different responsibilities at different levels resonates with the multi-level governance (MLG) perspective where transport policy implementation occurs at different levels (local, national, supranational) of governance (Zhang et al., 2019). National governments are the leaders in transport policies and at this level of governance national plans and strategies are devised and implemented. Towns and cities can make a significant contribution to transition to sustainable transport futures (McGuirk et al., 2015). Despite their limited power and resources, local governments have a huge potential when it comes to the implementation of transport climate policies (Butterfield et al., 2017). The multi-level governance perspective suggests that there are a range of policy measures which could be implemented at the local level to reduce emissions and shift to more sustainable forms of transport. They include the introduction of limits on parking, smarter choices, operation of a shuttle bus service in towns, and investment in walking and cycling infrastructure at the local scale (Marsden et al., 2010).

## 8.5 Citizens' views on policy pathways for sustainable transport futures

The last part in the transition phase of the backcasting exercise aimed to include the citizens' views into the design of policy packages. This stage took the form of a workshop which engaged a group of ten citizens as outlined in the methodology Chapter 4 (Section 4.8.2). Engaging the citizens in the transition phase of the backcasting exercise is an important step in the whole process and ensures more effective and implementable policy pathways. The main aim of the citizen workshop was to ensure that besides having good emission reduction potential and stakeholder interest, the alternative transport futures also have the potential to be adopted by the citizens.

Several key criteria determine the success of climate policies, including the cost to society, political acceptance and citizen support, all important aspects that determine the success of policy measures (Goulder and Parry, 2008). This is also true for transport policies that aim to shift towards more sustainable forms of mobility and reduce emissions. Amongst the criteria, lack of public support is a major barrier to transitioning to a low-carbon economy (Geels 2013; Wiseman et al., 2013). Citizen acceptability is one factor that needs to be considered during the design of effective climate policies. Creating public acceptability for sustainable mobility measures requires explaining the need for change in behaviour and convincing the citizens of the importance of their contribution (Banister, 2008).

The Theory of Social Practice again served as the basis for incorporating citizens' input into the design of policy pathways that can contribute to the achievement of the alternative transport futures. This stage of the research was aimed at identifying the citizens' support for the policy pathways which were designed by the stakeholders. The workshop served two primary functions. First, it was useful to establish citizen-consumer positive and negative evaluations of the alternative futures and the policy pathways for achievement of these futures. It also served to explore any recommended modifications to the proposed policy pathways.

Through the workshop, the researcher aimed to identify how the day-to-day lives of the citizens would be impacted if the different policy pathways are to be implemented under the three transport future scenarios. Such an exploration, allowed for the uncovering of those elements of the mobility practices which are important for the transition to the alternative transport futures, but which were not targeted by the policy pathways designed by the stakeholders. This is important for the successful achievement of the alternative futures since the successful recruitment of individuals to the reconfigured mobility practices or more sustainable forms of practices depends on the availability of the constituent elements making up these practices. The lack of available elements of the new or reconfigured practices will create citizen opposition and barriers to the successful implementation of the policy pathways. For example, providing cycling infrastructure may not be effective in recruiting more individuals into the practice of cycling if meanings relating to cycling are not addressed. This stage of the backcasting was aimed to further improve the policy pathways generated through previous phases of the backcasting methodology.

This last stage of the backcasting process was also aimed to explore the citizen's preference towards different alternative transport futures for 2050. Finally, the citizens were involved in the design of policy pathways for their preferred transport future. Incorporating the citizens and their views on policy pathways makes the backcasting process more democratic. This investigation will feed into the backcasting framework and further improve the policy pathways developed in the earlier phases.

### 8.5.1 Perceived impacts of policy pathways on citizens' daily lives

The input provided by the participants during the interactive session was recorded through the *Ahaslides* (https://ahaslides.com). Following the workshop, this data was downloaded and analysed. The data gathered during the interactive session consisted of individual statements for each of the policy measures showing their influence on the daily social practices as shown in Figure 8.4 and represent the participants' response to different types of policies.

The data was analysed using both quantitative and qualitative methods of analysis. The responses were first analysed quantitatively to provide an indication of the positive or negative evaluation for the different policy measures. Additionally, the data was also analysed qualitatively using the principles of the Theory of Social Practice as the guiding principle. The results of this analysis will be presented in the next sections.


**Figure 8.4: Example of citizens' response to different policy measures**

### 8.5.2 Response to policy measures

The responses were first analysed by the researcher quantitatively. For each of the policy options, the statements of the participants were classified into two groups. The first group represented those statements where the participants said that the policy measure would not hinder or have a negative impact on their day-to-day mobility needs. On the other hand, the other group represented those statements where the participants said that the policy option would make it difficult for them to attend to their day-to-day activities. Following this classification, an index showing the degree of positive responses was calculated for each of the policies which the participants were presented with during the workshop. The quantitative analysis is defined in Chapter 4 (Section 4.8.2).

The results of the quantitative analysis of the data collected during the citizen workshop is summarised in Figure 8.5. For each of the transport visions, the chart illustrates the degree of positive response towards the different transport policies. The indicator which is listed adjacent to each of the policies was determined by calculating the fraction of positive responses from the total responses which were inputted by the participants session. A value of 1.0 in the chart indicates that all the statements for that policy measure were positive and the participants believe that such a policy would allow them to meet their mobility needs in their day-to-day lives. On the other hand, a value of 0.0 would show that the participants perceive such a measure would hinder them from participating in their daily practices. Figure 8.5 shows that policies aimed at improving the bus system and those providing for a better cycling infrastructure and information for cyclists received the highest degree of positive response from the participants. In their comments, the citizen’s state that such measures would help them to meet their day-to-day mobility needs better while at the same time help them shift to more low-carbon forms of travel. The participants also showed high degree of support towards those policies that target land use planning and those that promote teleworking. On the other hand, the participants perceived legal measures that restrict car ownership and additional taxes on vehicle ownership would inhibit their travel needs and make participation in their day-to day activities more difficult.

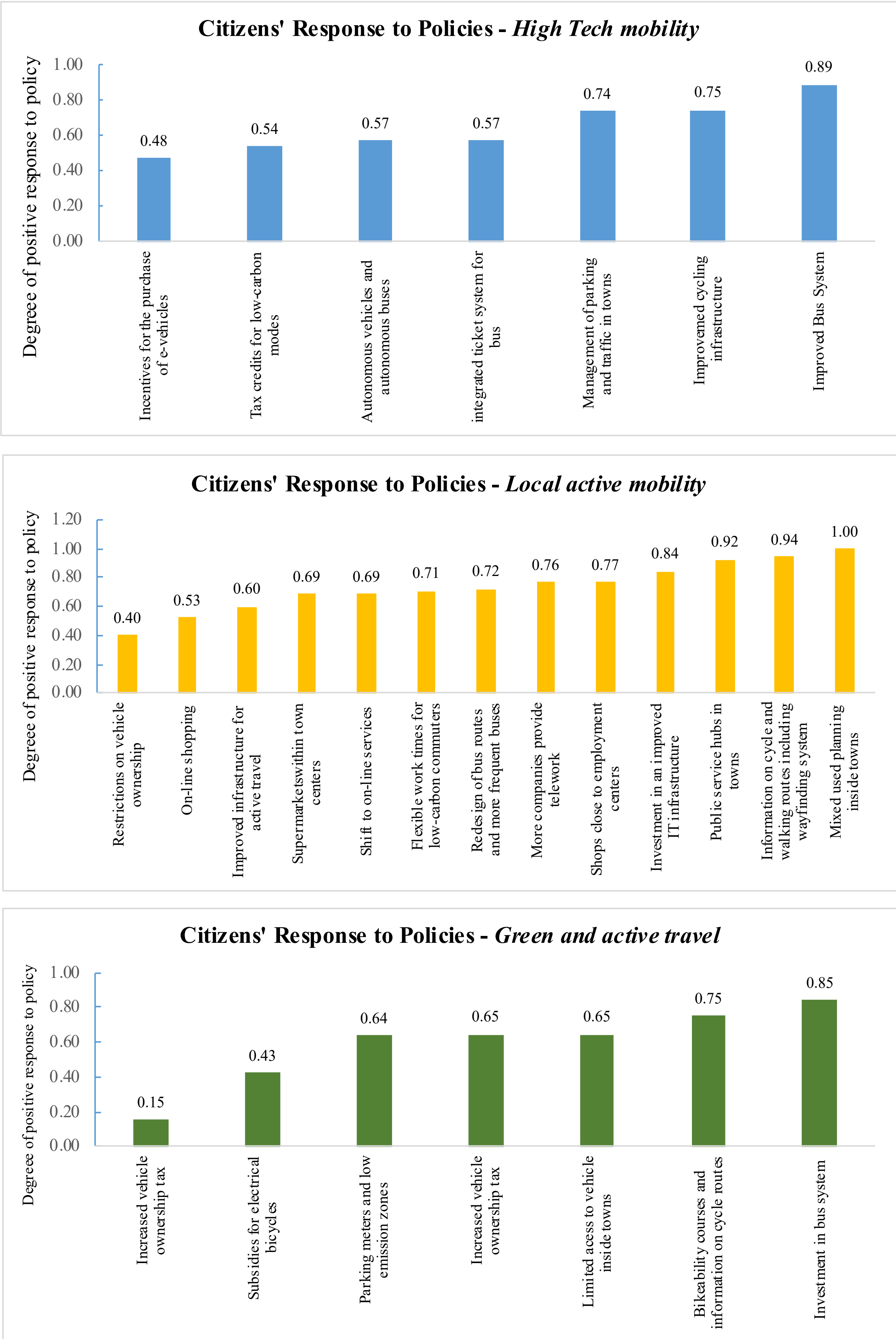



**Figure 8.5: Degree of positive response to different policy measures**

### 8.5.3 Policy measures and daily social practices

***Alternative transport future 1***

During the interactive workshop the citizens were presented with the policy options designed by the stakeholders and aimed to achieve the first of the alternative transport future for 2050 in Malta. This first alternative transport future describes a future where technology has changed such as to allow transition from car-based transport to a mass transit system. This system allows for rapid movement of people and goods and enables a future with busy lifestyles. The policies designed for this future included a mix of physical or infrastructural measures together with economic measures and those targeted at changing behaviour.

During the interactive workshop, the participants were given the space to provide their view and express their ideas on the proposed policy pathways and provide feedback on the impact of the policies on their day-to-day life if the policies were to be implemented. The participants responded to the policy proposals through the web application. The participants responses were in the form of statements which answered the question "if the policy measure is implemented, what changes do you foresee to your daily practices?" The responses were saved on the on-line platform and later extracted for analysis.

The citizens demonstrated general positive feedback for those policies which would improve the current transport system through the investment of an efficient mass transit system. The statements given by the participating citizens illustrate how the proposed policies would help them shift from the current and unsustainable car-based mobility practices to mass-transit system while at the same time being able to perform their day-to-day activities. The citizens argued that an efficient mass transit system with a frequent service with short walking distance to transit stops encourages individuals to shift to this mode of transport. The feedback of the citizens highlight the importance of having a highly efficient and reliable public transport system that can compete with the efficiency of the car. The following are some examples of the statements provided by the participants during the workshop, the number in brackets refers to participant number for the workshop.

*"I would be more inclined to use the buses if a bus stop is located near me and more frequent buses are provided"* (Participant 7)

*"Public transport will become faster than private transportation"* (Participant 3)

*"Increased efficiency and reliability making public transport more attractive"* (Participant 2)

Using public transport for shopping is still perceived to be difficult, suggesting that further focus on how policy can address the inter-link between shopping and mass-transit use is needed in order to allow individuals to use this transport mode. This could be in the form of innovative carrier bags that allow individuals to carry goods on the mass-transit system or more stops closer to retail outlets. Policies, such as educational campaigns, which target changes in practices of shopping for example buying few items at the local store and avoiding large shopping at the supermarkets, may remove this barrier to public transport use.

"*I would use the bus to move around. Shopping (which I do on a weekly basis) would be more complex"* (Participant 5)

Similarly, during the interactive session, the participants showed that most of them support the idea of the introduction of autonomous vehicles and feel that these would allow them to meet their mobility needs while attending to their day-to-day activities. Some of the participants stated that this type of transport would allow better use of time during the commute. The data also shows that despite the participants' willingness to use autonomous cars and buses, they are still concerned about the cost of travelling with such means of transport, the safety of this mode of travel and its efficiency.

"*Yes, I would definitely use these if prices are reasonable and they have good connections"* (Participant 7)

*"I would consider using such buses depending on the level of safety"* (Participant 1)

The same level of support was observed among the participants for policies that are aimed at improving the cycling infrastructure. In general, the participants stated that having an infrastructure that would make cycling safer would help them shift to this mode. Participants also highlighted the importance of having car-drivers who are aware of cyclists on the road, which in turn improves the feeling of safety and encourages more cycling. Cycling skills are also perceived as necessary by the participants for them to shift to bicycle use. The participants showed a good level of support for policies that aim to improve multimodality. In their comments, the participants stated that these would facilitate their shift to bicycle use.

*"Cycling is extremely efficient. If it becomes safe, I will cycle everywhere"* (Participant 3)

According to the citizens' views, incentives for the purchase of e-bikes would further aid in enabling the participants to change their mobility practices from car to bicycle.

*"Financial incentives will always make an option more attractive"* (Participant 8)

While incentives would help the purchase of e-vehicles, the same cannot be said for the uptake of electric cars. The participants, in their input, showed that there are other factors other than the cost of buying a vehicle that come into play when deciding to purchase and use an electric car to perform daily practices. These include the availability of charging points especially when the user does not own a garage and needs to find a way of charging the vehicle. The cost of changing the battery and maintenance of the vehicles are other factors that influence the citizens' decision.

*"I do not have a garage, so unless fast charging is available, I cannot make use of this technology"* (Participant 10)

*"Incentives would help the purchase of e-vehicles, but maintenance costs have to reduce, as well as the price of automobile lithium batteries"* (Participant 5)

***Alternative transport future 2***

The policy pathways designed for the second transport future encompasses a mix of policies which include both infrastructural measures, legal policies that aim to deter car use and behavioural change policies. During the interactive session with the citizens, the participants showed a high degree of support for those policies aimed at bringing about behavioural change. In response to these policies, most of the citizens taking part in the workshop stated that policies that encourage teleworking and other ancillary measures such as the provision of a good IT infrastructure that would help the shift to teleworking would impact their day-to-day activities in a positive way. The participants showed positive feedback for the policy pathways designed for alternative transport future 2. From the data collected during the workshop, the citizens indicated that in this alternative transport future they would be able to complete their routine activities more easily as they reduce the travelling time to and from the workplace.

*"Telework will reduce the time wasted in commuting and help me be more productive during the day"* (Participant 7)

*"Yes, teleworking would positively impact my daily life, time management and family life"* (Participant 6)

*"It would definitely mean less traveling and allow for more time to take care of myself and do other activities"* (Participant 9)

Other participants showed their concern over the lack of social interaction and sense of teamwork at the workplace which would result from teleworking.

*"It has pros and cons. I enjoy seeing my colleagues or having that contact with people in person"* (Participant 3)

The availability of flexible working hours for commuters who shift to active forms or low-carbon types of travel also received positive responses from the participants with them stating that such measures would help them improve time management and meeting their daily routines.

*"Flexibility could improve my family life"* (Participant 4)

*"Would be something to consider as it gives you time to plan other activities"* (Participant 1)

From the statements provided, it also becomes clear that such measures would encourage shift to low-carbon modes especially bus where punctuality may have been the major barrier for the participants to shift to public transport. Such initiatives would serve to reduce the stress which participants experience when trying to make their way between the different daily activities.

Physical measures aimed at reducing the travelling time and hence encouraging the uptake of walking received positive feedback. The practice of shopping would be facilitated if as part of land use planning, supermarkets are located within the town-centres rather than at the periphery. These can be easily reached on foot eliminating the need to use the car and the stress of driving that is usually associated with this mode of travel. Small grocery stores in villages can also lead to less food waste as smaller shopping baskets will be needed and food is used within its shelf-life. Such measures would also help to boost social life and facilitate this practice for users which do not drive a car. The participants also described how more frequent trips to the supermarket can help them buy the quantities they require and reduce wastage.

*"Yes, this will reduce the need to travel at other places to perform my shopping as long as the prices are reasonable, and they have fresh items"* (Participant 8)

For some others, carrying the goods from the supermarket might still be perceived as a barrier for shopping without the car. However, this difficulty could be overcome if the store provided delivery services. The availability of shops for daily needs close to employment centres such as University and large employment areas is perceived by the participants as a measure that would have a positive impact on their daily lives by reducing their need to travel and allowing more time for other activities.

*"This measure coupled with delivery would definitely work to reduce my number of weekly trips for foods"* (Participant 2)

*"This will reduce the need to travel as I can make the shopping and other tasks during the day"* (Participant 4)

The availability of local services in town centres is another measure that the participants find useful to facilitate their daily social practices. In their comments they stated that such measure would reduce their need to travel which such services being more accessible through active forms of travel such as walking. From the perspective of the participants, having online services can also facilitate their day-to-day routines and reduced their need to travel.

*"It will reduce the need to travel to other towns in Malta"* (Participant 10)

*"It would mean that I can do things online and instead of going physically"* (Participant 6)

Information on cycling and walking routes including a wayfinding system is another measure that received a lot of support from the participants. In their comments the participants stated that having this information would decrease unnecessarily travel distance and improve the travel times.

*"Many shortcuts are unknown. These would decrease travel time considerably"* (Participant 3)

While the physical policies and those aimed at behavioural change received a lot of support from the participants, the same cannot be said for the restrictive measures that were designed to reduce car use. The participants stated how legal measures that would restrict vehicle ownership have a negative impact on their daily activities.

*"If it is too restrictive, it might limit my mobility"* (Participant 5)

*"Would be a hassle, especially when all family members work different hours and have different activities"* (Participant 4)

***Alternative transport future 3***

The third transport future developed during the earlier phases of the backcasting exercise, depicts a future where improved urban planning allows for a shift to more active travel. The policy pathways developed for these visions include a mix of legal measures, physical or infrastructural measures and measures aimed and changing behaviour. As observed for the other alternative futures, the participants showed greater support for transport policies that target infrastructural provision or behavioural change rather than the legal measures. Participants support measures that invest in the public transport system provision. The participants think that subsidies for the purchase of electrical bicycles, bikeability courses and information on cycle routes would help them shift from car mode of travel to the bicycle. However, the participants also stress that these measures are effective when the infrastructure allows for them to feel safe on their journey with this mode of transport.

*"Subsidies must be coupled with safe infrastructure and lessons to feel more comfortable. Some destinations are not that accessible and are linked by dangerous main roads"* (Participant 1)

The introduction of parking meters and low emission zones are perceived to have a significant impact on the lives of the participants and would make the participants re-think about which mode of transport they would use to complete their day-to-day activities.

*"It would have a huge impact on my day-to-day activities"* (Participant 6)

*"This would require me to possibly change my car ownership, rethink how many cars in the household"* (Participant 8)

Some also stated that they would consider such a measure to be unfair especially when they need to attend to the mobility needs of other persons.

### 8.5.4 Additional measures for policy pathways

The data resulting from the interactive workshop was also used to draw up information about the elements which the participants thought were not addressed in the policy pathways developed by the stakeholders for the three alternative futures. Qualitative data analysis was also employed to identify other areas of social life where policy can further intervene to enable the achievement of the alternative transport futures. An inductive-deductive qualitative analysis yielded a set of concepts, summarised in Table 8.7, which was used to further improve the policy pathways.

The data in Table 8.7, shows how participants identified missing material elements, but also the importance of competencies and meanings for achieving the alternative futures described in earlier phases. For alternative future 1, the participants emphasised the importance of an improved infrastructure for both public transport and active modes. Information on planning a multimodal journey and bikeability courses were seen as important policy interventions that would address the missing competencies. Policies that would make public transport low cost, reliable and comfortable were identified as important to contribute to positive meanings towards public transport use. During the workshop, participants discussed the need for additional policies policies that would make walking and cycling safe.

The discussions during the workshop and the subsequent data analysis reveal that polices for alternative future 2 should aim for and improved an improved IT infrastructure, internet platform and better urban planning in towns. From the participants input, competencies that allow individuals to travel using alternative forms of transport to the car, should also be the focus on policies for the future. Awareness campaigns about the benefits of active travel and policies which enhance the social life inside town centres were also amongst the suggestions put forward by the participants during the workshop.

When participants were asked to discuss the policy pathways designed by the stakeholders for alternative future 3, they suggested additional measures for a better public transport infrastructure and improved cycling infrastructure. Information on cycle routes and walking paths were also identified as being important to provide the necessarily competencies and facilitate the transition to active modes. The participants also highlighted the importance of making cycling safe and enhancing making town centres a space where individuals can socialise.

**Table 8.7: Results of the qualitative analysis of citizen workshop**

| **Alternative future 1** | | |
|---|---|---|
| **Materials** | **Competencies** | **Meanings** |
| Bus stops are within walking distance | Bikeability courses | Bus is efficient |
| Carrying capacity of the car still needs to be addressed | Information on how to plan a multimodal journey | Cost of public transport is kept low |
| Charging infrastructure must be improved | | Personal Space |
| Availability of garage for charging | | Comfort |
| Bus lanes must be segregated to allow for fast bus journeys | | Reliable public transport system |
| Parking from towns must be removed | | The cost of purchase of e-cars is not high |
| Local mobility for persons who cannot walk or cycle | | Safe cycling lanes |
| | | More awareness on the health benefits of cycling |
| Separate cycling lanes | | Tax benefits are a plus |
| | | Walking is safe |

| **Alternative future 2** | | |
|---|---|---|
| **Materials** | **Competencies** | **Meanings** |
| Good IT and electrical infrastructure | Information on how to travel without the car | Awareness on benefits of active travel |
| Improved internet platform for on-line shopping | More information for employers to help them shift to teleworking | Address the lack of social interaction created due to teleworking |
| Improved road enforcement | Information on the fastest routes to get around | Awarness on better work-life balance of teleworking |
| Access to different facilities within town centre | More awareness on how to integrate different activities within walking distance | On-line shopping should provide good prices to incentivise on-line shopping |
| Efficient deliveries for on-line shopping | | Social life inside town centres should be promoted |
| Services open also on weekends | | Feeling of community in towns is prioritised |
| Services at local scale | | |

| **Alternative future 3** | | |
|---|---|---|
| **Materials** | **Competencies** | **Meanings** |
| Bike racks | Information on cycle routes | Cycling must be made safe |
| Increase the accessibility of different destinations by bike | Information on how to make short trips on foot | Socialising in town centres in prioritised |
| Provide alternatives to bike to those who cannot cycle but still need to move around | Cycling routes to different destinations | Innovative and alternative modes of transport |
| Bus routes re designed to allow for more accessibility | | |

### 8.5.5 Policy pathways for Preferred Vision

During the second part of the citizen workshop, the participants were asked to vote for the future transport vision that they preferred. Alternative transport future 2 received the highest number of votes from the participants. The participants were also provided space to design a set of policy pathways which in their opinion would be able to achieve their preferred transport future. These policy pathways are projected in the short-, medium- and long-term. During this part of the workshop, the participants were guided to include in their pathways the policies which target different elements of mobility and are not only limited to the transport sector but target different areas of social life. Table 8.8 summarises the results of this exercise. The table shows a set of policies aimed to achieve future transport vision 2 and their implementation time-frame.

**Table 8.8: Missing practice elements from the policy pathways developed by the stakeholders, as identified by citizens**

| Short-term (2021- 2030) | Medium-term (2030 – 2040) | Long-term (2040 -2050) |
|---|---|---|
| Improve pavements for local travel | Redesign urban areas to allow for mixed used planning – 15 minute cities concept | Land use zoning |
| Lessons for children on how to ride a bicycle | More pleasant, safe and comfortable streetscapes | Reduce roads and increase green-parks |
| Teleworking | Priority to bus | Increase in pedestrianised roads |
| Walking buses for school children | Segregated and continuous cycle paths | Segregated and continuous cycle paths |
| Car-free town centres in off-peak | Incentives for those who make less use of the car | Vehicle ownership restriction |
| Shopping close to home | Government services in each town | |
| Walkable city | More leisure destinations within town centres | |
| Workshops at schools and universities informing students on how to walk and cycle safe to school and other nearby localities | With mixed used planning more leisure/cultural events may be organized all year round. | |
| More town centres with facilities in such as shopping, leisure and education | More traffic lights (which change frequently) | |
| | Disincentives for cars - reduce parking and sacrifice car lanes for non-vehicle transport. | |
| | Reduction of vehicle access from the town centres and introduction with a loop transport system which pick and drop of people from various points in the town centre | |
| | More education about proper road use | |

### 8.5.6 Refined policy pathways

The results of the qualitive analysis of the data gathered from the citizen workshop was used to refine the policy pathways which were initially developed by the stakeholders. The concepts from the citizen workshop presented in Table 8.6 include a list of elements of mobility practices which in the citizens' perspective were not addressed in the policy pathways developed by the stakeholders. The initial policy pathways were thus subjected to a process of refinement based on these concepts and as identified by the citizens. This process involved the addition of further policies to the initial pathways. These policies were designed to address those elements of mobility practices which the citizens felt were not covered with the initial policies.

For example, one policy which was included with the pathways for the first alternative transport future was a measure that would ensure that charging infrastructure for electrical vehicles is in place. Through the discussion during the workshop, the citizens emphasized that the lack of charging points for electrical vehicles is one of the barriers that hinders them from transitioning from the conventional vehicles to electrically powered ones. Similarly, policies which address the lack of social interaction caused by teleworking were included with the policy pathways for the second alternative transport future. The refined policy pathways are summarised in Figure 8.6.

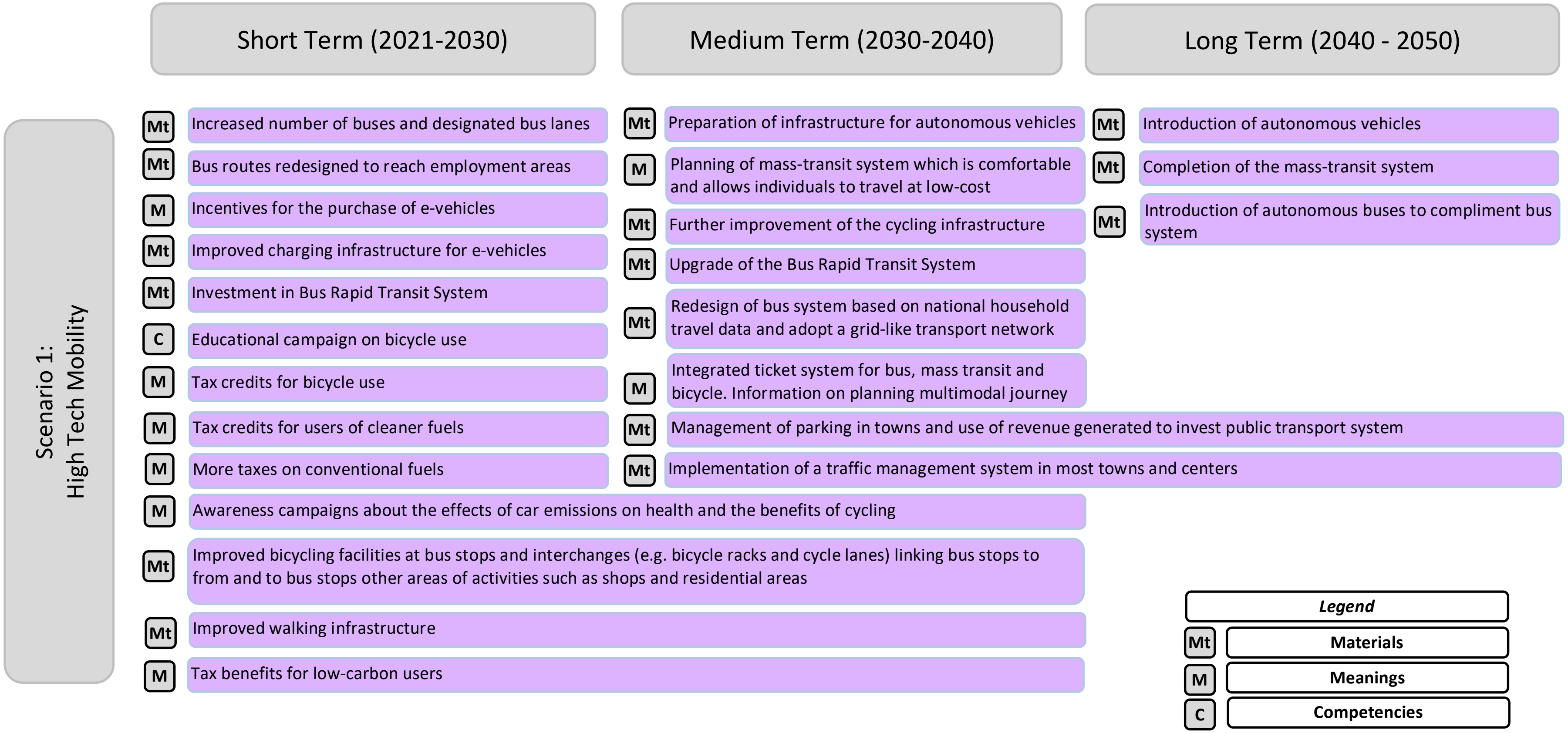



**Figure 8.6a: Refined policy pathways for alternative transport future 1**

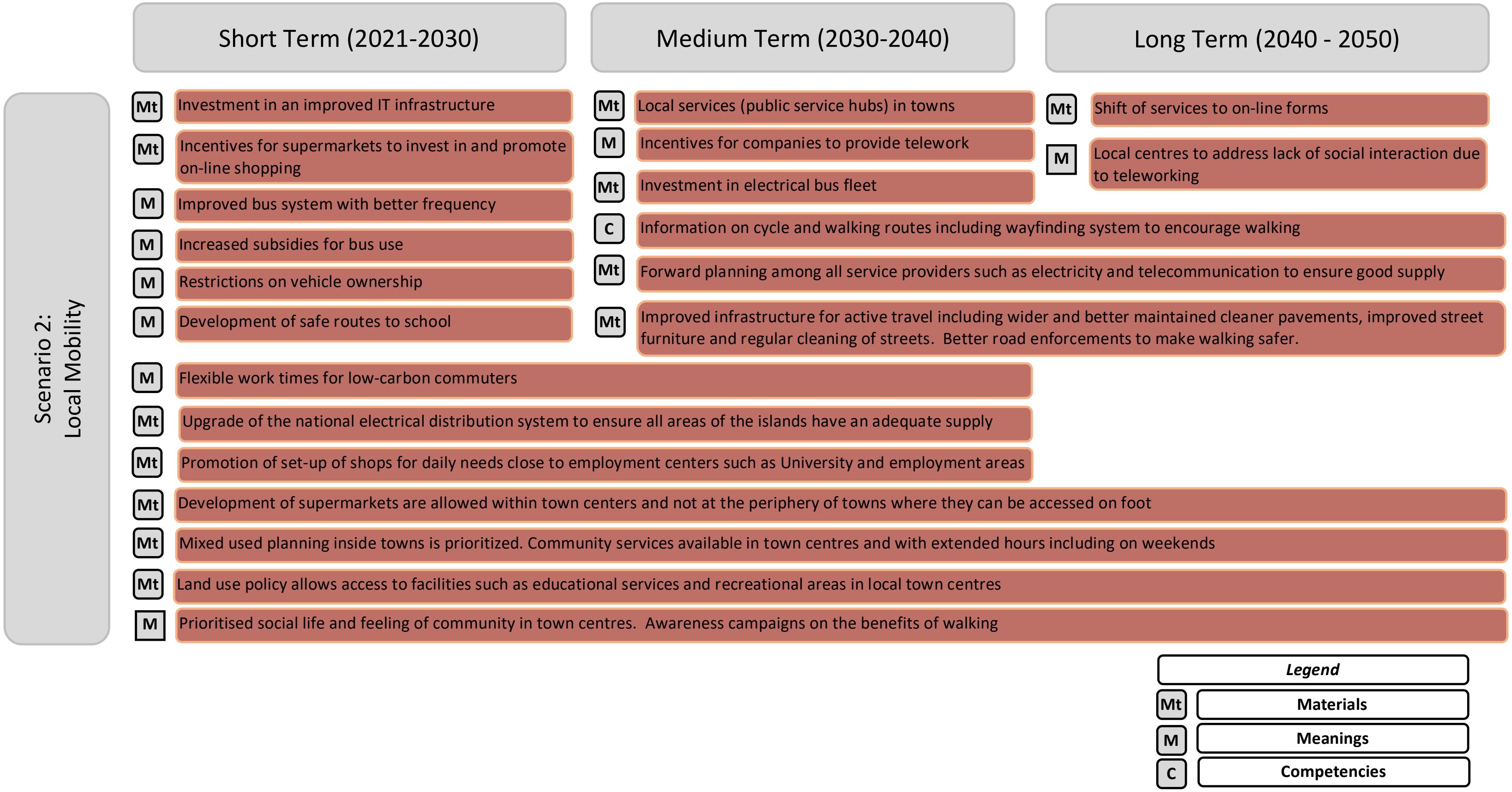



**Figure 8.6b: Refined policy pathways for alternative transport future 2**

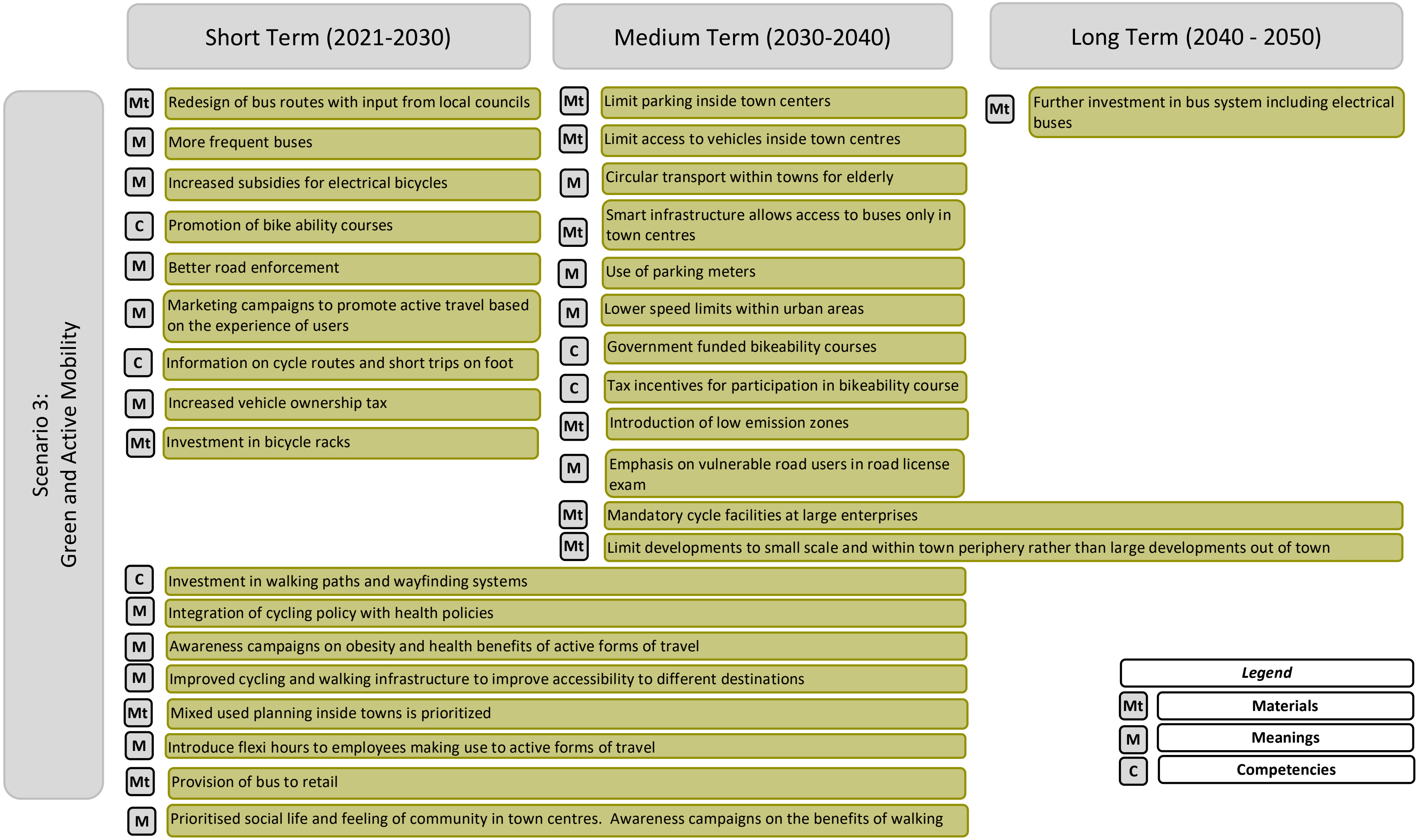



**Figure 8.6c: Refined policy pathways for alternative transport future 3**

## 8.7 Conclusion

The focus of this chapter was the transition phase of the backcasting exercise. It outlines the results of the stakeholder survey which was used to identify a set of policy packages to achieve the alternative transport futures. The chapter then described the outcomes of the interviews with a second group of stakeholders focused on the design of policy pathways for alternative transport futures. Finally, it identifies the citizens' views on different policy measures and how in the citizens' opinion the policy pathways can be improved to ease their implementation.

Through the survey, the stakeholders were guided to cluster a set of pre-defined list of policy measures into different policy packages for each of three alternative transport future scenarios. During the process the stakeholders were asked to define policy packages based on similarities in the target of the policies, packages that include measures that are likely to work together and packages which create positive synergies between measures and to add additional policy measures to the original set of identified policy options. The results of the qualitative analysis of the stakeholder survey produced a set of policy packages for the three alternative transport futures. The policy packages represent groups of measures which the stakeholders identified as having potential of delivering the alternative transport futures. The results show how the stakeholders chose different set of policy packages for the three alternative futures.

The second step in the transition phase of the backcasting process involved the refinement and elaboration of the initial policy packages. The second stage took the form of a set of interviews with a second group of stakeholders. The interviewees were then asked to define any additional interventions that would help to achieve the alternative transport futures and define ways in which policies can be further combined to increase their effectiveness, acceptability and feasibility. Timeframes and responsibility for the implementation of the policies and policy packages were also discussed during the interviews. The interviews were useful to reveal a set of distinct ideas about what policies and policy pathways can contribute to the achievement of the alternative transport futures. The qualitative analysis of the interview data produced three initial policy pathways which describe policies and implementation timeframes for the three alternative transport futures.

The last stage aimed to include the citizens' views into the design of policy packages. This stage took the form of a workshop which engaged a group of citizens. Engaging the citizens in the transition phase of the backcasting exercise is an important step in the whole process and ensures more effective and implementable policy pathways. The results of the qualitive analysis presented a set of concepts about the elements of mobility practices which in the citizens' perspective were not addressed in the policy pathways developed by the stakeholders. Based on these concepts the initial policy pathways were subject to a process of refinement which resulted in a final set of policy pathways.

The next chapter, Chapter 9, presents the discussion of the results presented in Chapters 5 to 8 in relation to findings from the literature. The final chapter, Chapter 10 follows the discussion and concludes the study.

# CHAPTER 9: DISCUSSION

This discussion builds on the previous chapters which have presented the results and main findings of the research. This chapter aims to provide an overview of the study and demonstrate how the overall aim of the research – *to analyse how a transition towards sustainable mobility can help achieve the climate change mitigation targets for Malta* – has been achieved. The research was conducted in phases producing four results chapters:

- Baseline and context in Chapter 5 provided an overview of the current mobility practices and their constituent elements. The influence of other social practices on mobility was also investigated.
- Visioning Phase in Chapter 6 was based on the results of the baseline and context study and reported on the results of a participatory workshop to develop future transport visions.
- Scenario suitability evaluation in Chapter 7 described the results of the transport modelling exercise used to assess the suitability of the alternative future visions.
- Transition phase in Chapter 8 adopted a participatory approach to design policies and pathways need to achieve sustainable transport in Malta in 2050.

This chapter will discuss these results in the light of the current literature. This will be followed by a discussion on the relevance of this research within the Maltese transport policy context (Section 9.2). The section that follows will discuss the strength and limitations of the research. The final section summarises this chapter and links to the conclusions in Chapter 10.

## 9.1 Discussion on findings

This section is organised according to the framework presented in Chapter 3 and the research agenda described in Chapter 4. The results discussed in this chapter reflect the different research questions and how each set of results leads to the aim of the research – that of developing policy pathways for the year 2050. The discussion starts by describing the current mobility practices, how these served as starting point for future visions, the assessment of these visions and the design of policy pathways.

### 9.1.1 Mobility practices

The results of the survey carried out with a sample of 400 individuals living in Malta showed that the car is by far the most preferred mode of travel, with 73% of the participants choosing the car as their preferred mode. Only 9% of the participants showed preference for active modes of travel such as walking and cycling. A large proportion of the respondents (79%) stated that they owned a car as a means of transport. These results were reflected in earlier studies (Attard, 2020) and in available transport statistics (Eurostat, 2020a) which have consistently shown the car-oriented transport situation in Malta. These travel patterns and the dominance of car travel is similar to those found in many other European cities and countries (European Commission, 2020c) and beyond.

This study further dissected car travel in Malta by examining trip purpose and activity at destination. Data on trip purpose is very useful for transport research which aims to investigate a shift to sustainable transport. Travel is a derived demand and understating travel requires an understanding of the activities for which travel takes place (Pendyala et al., 2002; Pinjari et al., 2011). Having a good insight into the purpose for which trips are undertaken and the activities at destination can help to contribute to a better design of interventions for transitioning away from car-based travel to more sustainable forms of mobility (Manoj Malayath et al., 2013; Mattioli et al., 2017). Despite the usefulness of such information, this type of data is limited in Malta, with only a few studies investigating trip purpose at destination (Maas, 2021b; Mifsud, 2018).

The results of this study showed that travelling for the purpose of work was the most common among respondents. This findings corroborates with other studies which have shown that commuting journeys are amongst the most common type of trips undertaken globally and on a daily basis (Singleton, 2018; Thomopoulos et al., 2021). Other non-work-related trips made for the purpose of visiting someone and to engage in educational activities were also amongst the most frequent trip purposes. These results suggest that while commuting is an important aspect of daily travel there are other activities outside work which have a significant influence on travel demand (Cerqueira et al., 2020).

Chapter 5 showed how mode choice varies with the activity at destination. For example, most of the trips made for the purpose of accompanying a child are made by means of a car. This observation is also confirmed in other studies which concluded that the presence of a child in the household increases car-based trips (Aguilera et al., 2009; Cerqueira et al., 2020; Mattioli et al., 2016). And whilst car-based travel is the preferred mode choice for work trips, using the bus has a higher incidence for community activities and engagement in education.

Trip durations recorded from the survey were relatively short with a mean of 30.36 minutes, indicating the short distances between sites of different activities. The average trip by car is generally shorter than that made by bus (28 minutes of an average trip by car versus 42 minutes for an average trip by bus). These figures are in agreement with recent studies which found that journey times by bus are significantly longer than those by car (Mifsud et al., 2017) and national data which have shown that the average journey by car was of 19 minutes and that by bus was of 48 minutes (Transport Malta, 2016b). This may highlight a potential barrier towards a shift from car-based travel to bus type journeys, where preference is given to modes which allow individuals to travel in shorter times (Cass et al., 2016). Average trip durations of 25 minutes and 34 minutes were reported for walking and cycling respectively in the survey which are in-line with studies showing that acceptable walking and cycling times are of 22 and 35 minutes (Heinen et al., 2010; Metz, 2021).

Interview data provided a more in-depth view of the influences on mobility practices. Results from the qualitative analysis served to uncover elements of low-carbon mobility practices that are necessary for the shift from car-based travel but may not be available to potential practitioners. The results also demonstrate the embeddedness of mobility practices in everyday life and how lifestyle and day-to-day activities shape modal choice.

The outcomes of the interviews have shown that one of the most important elements that makes car driving a popular mobility practice is the carrying capacity of the car. These findings are in-line with the current literature on the motives for car use, where it is widely acknowledged that the practical aspects of car use are positively valued (Steg, 2005; Steg et al., 2005). Research has shown that one of the motivations to car use is associated to the instrumental-function of the car which provides flexibility, fast travel times and a means to carry one's purchases (Bergstad et al., 2011; Lois et al., 2009).

On the other hand, the lack of cycling and walking infrastructure are two material elements that hinder the recruitment to these practices. This is in agreement with other studies on active forms of travel which have found provision of proper infrastructure achieves higher level of cycling and walking (Moudon et al., 2005; Pucher et al., 2008b). The analysis of interviews from a Theory of Social Practice perspective has also revealed that most of the population seems to lack competencies required for cycling with some individuals stating that they wish to start cycling but feel they lack the skills or are afraid of using this mode of travel. The results are comparable to similar studies investigating cycling in the UK (Spotswood et al., 2015), where competencies related to cycling were found to be missing from the adult non-cycling population. The same conclusions can be made on the level of fitness required for individuals to take up cycling. These results are also concordant with those in other studies (Spotswood et al., 2015).

When it comes to using the bus, the data from this study shows that negative meanings associated with bus travel contribute to discouraging bus use and include problems with the buses being too crowded, low service quality and discomfort during the journey (Stradling et al., 2007). In addition, the results of the interviews also shows that traveling with the bus is time consuming and push individuals towards travel with the personal car in an attempt to minimise travel time (Metz, 2008a).

It is evident from the analysis that there is an influence of other social practices on mobility. The fixed timings for work and school, parental responsibilities, shopping and other activities shape the recruitment of individuals to different forms of travel (Iyanna et al., 2019; F Meinherz et al., 2020; Shove et al., 2015; Spurling et al., 2014). In agreement with other studies which have looked into mobility practices, work clearly has a substantial impact on the recruitment to specific practices over others (Cass et al., 2016). The data gathered through the interviews has shown that the advent of children has important effects on travel. Other studies (He, 2013; Pooley et al., 2011), have come to the same conclusions on the parents' role and the need to coordinate not only their activities, such as work, but also tend to the traveling needs of their children. This increased need to move between different sites drives individuals to adopt mobility practices which are most efficient in terms of time, and often lean towards car use. The practice of shopping, especially when shopping for grocery at large peripheral supermarkets, was also shown to push individuals towards car use, which form of mobility enables them to reach destinations which otherwise are difficult to get to and also help them in transporting their purchases home (Berg et al., 2020; Mattioli et al., 2016).

### 9.1.2 Transport future visions

This section discusses the findings related to the development of alternative transport visions for Malta for the year 2050. Three alternative scenarios were developed through a participatory approach and concepts from the Theory of Social Practice. Participatory vision development has been found to be an adequate approach to explore system innovations and transitions towards sustainability (Quist et al., 2011). Participatory approaches offer a number of advantages over other approaches of scenario development, including expert led approaches which are more common in transport policy making (Banister et al., 2013). As discussed in the literature review presented in Chapter 2, practice-theory offers an innovative approach to sustainability transitions. This section will discuss the main advantages and lessons learnt from the adoption of practice-based participatory approach to future visioning.

***Selection of participants***

The selection of the participants was an important aspect of the visioning process. Since the aim of the visioning phase was the development of normative views of the future, normative stakeholders were invited to participate in the visioning exercise (Wangel, 2011a). The selection of the participants reflected an emphasis on integrating different perspectives during the visioning process and included a wide range of stakeholders with members of the public, academics, transport practitioners, NGOs and policy makers. The heterogeneity of the stakeholders provided an opportunity for bringing together different views and ideas about transport and other socio-technical systems that have an influence on mobility. The need to have a broad diversity of actors in the backcasting approach which is so important in the complexity of reaching low-carbon futures, is noted in other backcasting studies (Carlsson-Kanyama et al., 2008; Kalnins et al., 2015; Mander et al., 2008a; Melander, 2018; Quist et al., 2006; Soria-Lara et al., 2017b)

The workshop setting provided a space where a range of stakeholders could discuss ideas about the future while moving away from their interest and personal views. The usefulness of workshops for bringing together different ideas was also demonstrated in other backcasting studies (Carlsson-Kanyama et al., 2008; Kok et al., 2011; Patel et al., 2007). The discussions during the visioning phase enabled the participants to devise innovative ideas and alternatives for the current mobility practices as well as ideas that may contribute to ways in which to achieve the visions. One of the main advantages of using participatory methods in visioning is that the scenarios developed are owned and resonate more with a wider range of stakeholders rather than a group of experts and are hence more likely to be implemented successfully (Banister et al., 2013; Olsson, 2015).

***Sample size***

The number of participants in the visioning workshop was also a critical factor for the results of the study. The selection of the sample size was made so as to keep the number of participants minimal (n=21) while at the same time engaging a broad range of participants. A small group, where each of the participants could contribute and have enough time to participate in the conversation was found to work well for the visioning workshop. This finding is in-line with similar backcasting studies which have employed a small sample size during the visioning exercise (Andersen et al., 1999; Crane et al., 2003; Zimmermann et al., 2012a).

***Multiple alternative futures***

The engagement of different stakeholders in the visioning workshop served to provide different alternatives to the current unsustainable scenario. This type of participatory vision contrasts with the more common expert-led processes. It represents a bottom-up method for designing alternative futures and provides a more democratic means of thinking about the future (Mattila et al., 2011; Shiftan et al., 2003). The aim of the visioning workshop was not to reach consensus amongst the participants on one alternative transport future vision, rather the aim was to explore different alternatives that could contribute to the emission reduction targets. The main advantage of exploring different ideas and visions is the development of more radical scenarios including ideas that might not have been thought of (Julsrud et al., 2015; Soria-Lara et al., 2017b). The result of such process was the development of three alternative future visions as starting points for the backcasting. Development of multiple future scenarios also been the focus of other transport backcasting research (Tapio, 2003; Tuominen et al., 2014; Warth et al., 2013).

***Developing higher order learning***

One advantage of applying a participatory approach to the development of future visions is their potential to develop higher order learning amongst the participants (Quist, 2007). Higher order learning has the potential of initiating wider social change when compared to sustainable consumption based on individual ideas (Schröder et al., 2019) and occurs when participants in discussive exercises change their interpretive frame and their problem definition as a result of interaction with other participants (Quist, 2007; Vergragt et al., 2007). In this study higher order learning was possible through the engagement of multiple stakeholders who brought to the discussion different views and perspectives about the future of transport in Malta. The workshop setting was crucial to foster collaboration between stakeholders during the visioning exercise. The use of online tools for engaging participants during the workshop was important to allow the participants to bring together different ideas and initiate discussion between participants. These findings are in agreement with other studies which have also commented on how online workshops offers the potential to increase the volume and diversity of participation and participant interaction (Lyons et al., 2021; Wright et al., 2019).

While the results of the visioning exercise indicate that there was collaboration between stakeholders during the workshop and higher order learning amongst participants, further investigation would be required to assess the level of this high order learning. For example, this study could have been improved by including a survey with the participants following the workshop to gauge their opinion on the social learning aspect of the process (Doyle et al., 2013; Kok et al., 2011).

***Practice-based visioning***

The study has demonstrated the application of a Theory of Social Practice based approach to transport future visioning. The approach has been tested in other policy areas (Doyle et al., 2013), however it is innovative in transport research. The use of social practices in combination with the visioning exercise has allowed a greater reflection on the social and cultural context when considering alternative transport futures. The visioning exercise was structured to guide the participants to think in terms of all the elements (materials, competencies and meanings) of mobility practices when designing alternative futures. The innovation that the Theory of Social Practice approach can bring to transport policy making is exemplified by the scenario types developed in this study. For example, the visions created in this study depict a future where individuals are using more active forms of travel to meet their mobility needs. Such futures are indeed similar to transport future scenarios created in similar backcasting studies (Geurs et al., 2010; Soria-Lara et al., 2017b; Tuominen et al., 2014). However, the visions created in this study go beyond the provision of material elements such as walking infrastructure to promote active travel. The practice-based visioning exercise recognises that engaging in walking not only necessitates the availability of walking paths, but also the information necessary to help individuals navigate their way to their destination and how fostering positive meanings for walking are also important for the shift to low-carbon forms of travel.

Furthermore, a practice-oriented approach to transport visioning resulted in changes not only in transport but in other non-transport practices which have implications for mobility demand and the possibility of low carbon mobility. The visions created in this study are different from other forms of visioning which have focused on how changes in vehicle technology or land use planning might bring about the required cut in emissions from transport (Tuominen et al., 2014). For example, the futures created in this study, describe scenarios where changes in the way individuals work, engage in education, or do their shopping might decrease the mobility needs or allow individuals to move away from car-dependent travel.

### 9.1.3 Scenario suitability evaluation

This section discusses the findings related to the assessment of the 2050 alternative transport visions for Malta for their potential to reach the emission reduction targets. The evaluation of the alternative transport scenarios was based on the UNECE model 'For Future Inland Transport Systems' (ForFITS) model (https://unece.org/forfits-model-assessing-future-co2-emissions). The output of this modelling exercise produced estimates for $CO_2$ emissions from the road transport sector for 2050 for each of the alternative futures.

***Implications of the modelling results***

The results of the modelling exercise were useful to demonstrate the potential of the alternative transport future scenarios in meeting the targets of climate change mitigation from the transport sector (80% reduction from the current GHG levels). The results presented have shown how the target of 80% reduction was difficult to achieve under all three alternative future scenarios.

Future scenario 2 - *Local Active Mobility* - demonstrated highest potential in reducing emissions. Under this scenario, the emissions were reduced by 74%. Future scenario 3 - *Green Active Travel* – has the potential of cutting emissions by 68% when compared to the BAU. On the other hand, only a 36% cut in emissions is possible when scenario 1 - *High Tech Mobility* - is considered as the alternative future.

The significance of these results lies in highlighting the difficulty and the nature of the challenge involved in the decarbonisation of the road transport sector. Drastic changes are necessary to the current mobility conditions in Malta to reach the 80% reduction target. The results of the scenario assessment is also useful to assess how the alternative futures developed in this study compare to the current national plans and strategies for transport in Malta. In 2016, Transport Malta published the first National Transport Strategy 2050 (Transport Malta, 2016a)), which sets out the longer-term goals for the Maltese transport system. This was followed by the publication of the Transport Master Plan 2025 (Transport Malta, 2016c) which proposes plans, policies and measures to meet the goals set in the transport strategy (TM, 2016b). This last document proposes alternative policy scenarios which represent different levels of policy implementation. These scenarios were subject to an appraisal for the purpose of assessing their suitability towards the achievement of the goals of the transport strategy. One indicator used to appraise the alternative policy scenarios set was the $CO_2$ emissions under each scenario. Table 9.1 summaries the alternative policy scenarios as set in the Transport Master Plan 2025 and estimated emissions under these scenarios.

**Table 9.1: Summary of scenario appraisal presented in the National Transport Master Plan**

| Scenario | Description | Estimated CO2 emissions (tons/year) |
|---|---|---|
| Do-Minimum | Minimum expected changes and those committed developments | 342,642 |
| Do-Something 1 | Moderate restraint in the use of private cars and increased support of public transport and alternative modes | 314,319 |
| Do-Something 2 | Strong restraint in the use of private cars and strong support to public transport and alternative modes | 284,736 |

*Source: Transport Malta (2016c)*

The results of the evaluation conclude that under these scenarios, the transport activity (measured as total distance travelled) will continue to increase by 2025. The results also show that the transport future scenarios Do-something 1 and Do-something 2 have the ability to decrease the $CO_2$ emissions by 8.3% and 1.9% respectively when compared to the Do-Minimum scenario (Transport Malta, 2016c). These results indicate that more radical solutions are required to the current national policies for significant reductions of the $CO_2$ emissions. In comparison to the current transport plans for Malta, the alternative scenarios developed during this study show higher potential for limiting emissions from the transport sector. This is of significance to the implications of this study in the context of the current transport situation in Malta. The scenarios proposed in this study may serve as a starting point into thinking about alternative futures to the current transport policy.

***Suitability of the alternative futures for $CO_2$ emission reduction***

The scenarios developed in this research describe different futures for the transport sector in Malta in 2050 which include different assumptions about the way individuals will travel in these futures. Scenario 2 – *Local Active Mobility* – was shown to have the highest potential for reducing emissions when compared to the other alternative future scenarios. This scenario describes a shift away from car use to forms of travel which do not require large travel distances and which are very feasible with active modes of transport such as walking and cycling. Commuting by car would be greatly reduced as internet allows teleworking. Future development in ICT and fast digitalisation can offer the opportunity for individuals to perform numerous activities online without the need to physically travel (Gössling, 2018; Mouratidis et al., 2021). The scenario implies major changes in travel behaviour and the structure of the towns and cities. Planning and design of the cities needs to take into consideration the spatial and temporal of the communities and provide the individuals with necessary services, which can be reached on foot or by bicycle within a few minutes (de Valderrama et al., 2020). More space for cycling lanes and footpaths needs to be made available leading to a positive impact on the quality of life in urban areas.

Scenario 3 – *Green Active Travel* – also describes a scenario with a strong shift away from car-based travel. In this scenario urban planning is highly prioritised with the planning of green spaces and infrastructure for cycling and walking.  This future is also charaterised by an improved public transport system which further reduces car-based travel. Urban form and planning of urban areas play an important role in the sustainability of cities and urban areas. For example, planning for more open spaces and green infrastructure within the urban concentrations has been shown to have the potential of contributing towards more sustainable transport (Austin, 2014; Benedict et al., 2002; De la Sota et al., 2019). A recent study for Malta has identified ample opportunities for the re-design of urban open spaces which have the potential to act as green infrastructure and provide a network of connected open spaces which can contribute to more sustainable urban areas (Scheiber, 2020, 2022).

Scenario 1– *High Tech Mobility* – shows least emission reduction potential. It describes a future with an emphasis on technological change, investment in mass transport system and reliance on electrification of the vehicle fleet. This scenario represents a future which is most difficult to implement when compared to the other alternative scenarios. A future described by Scenario 1, would require a strong investment in technology, a strong market uptake of electrical vehicles and further development in vehicle automation (Guo et al., 2021; Staricco et al., 2020). Despite the potential of technological change and shifting to cleaner forms of power in reducing emissions from transport, their penetration and acceptance in urban transport is known to be difficult to achieve (Bastida-Molina et al., 2022; Biresselioglu et al., 2018).

Overall, the results of the modelling exercise carried out as part of this backcasting study show that decarbonisation of the transport sector is very difficult to achieve. Policy measures with a focus on one aspect of the transport system such as technology or modal shift may not be sufficient to meet the GHG emission reduction targets. This means that the targets may be more feasible with the adoption of policy mixes. A future which includes a mix of concepts from all futures would have a higher potential of meeting the emission reduction targets when compared to the individual futures. Literature on sustainable transport and alternative futures (Banister et al., 2013; E. Menezes, AG. Maia, et al., 2017) similarly point out how diversified mixes of policy options have greatest potential to reduce emissions from the transport sector.

***Uncertainties***

The modelling exercise is the result of a complex process which takes into account numerous variables which are altered over the long term to project GHG emissions of the transport sector under different conditions. This long term forecasting is subject to a number of uncertainties which arise from the prediction of future conditions (J Zawieska et al., 2018).

One major uncertainty which is especially relevant to the modelling of the BAU scenario is due to the prediction of the performance of future vehicle technologies and fuels (Bastani et al., 2011). Changes in vehicle technology and energy efficiency is difficult to predict over the long term and can significantly be affected by national and regional variables. Uncertainties are also amplified from the interaction between different variables during the running process (Wen et al., 2016). The ForFITS model is strongly dependent on the use of economic indicators for estimating future transport activity and GHG emissions. Another source of uncertainty of the model is the result of its limitation to factor in new transport technologies and services such as mobility-as-a-service (MaaS) solutions (J Zawieska et al., 2018). Other uncertainties are evident when modelling the alternative future scenarios. For example, the impact of policies related to teleworking which are influenced by several factors, are difficult to model. Similarly, the impact of increased green spaces and walking infrastructure on the transport system is complex and contributes to a high level of uncertainty (E. Menezes, AG. Maia, et al., 2017).

To reduce the uncertainties from the modelling exercise, the estimation of the GHG emissions was based on reliable data sources and current transport modelling methodologies. The modelling results were successfully validated against other independent projections of $CO_2$ emissions under the BAU conditions. Model validation is a critical step to ensure the accuracy and reliability of the model results with actual statistics. Modelling results from this study were found to be compliant with the national projections of GHG emissions which Malta reports to the European Commission as part of its obligations under the Monitoring Mechanism Regulation (European Commission, 2013). This validation is important for this research, and it demonstrates the reliability and the robustness of the modelling results.

### 9.1.4 Development of policy pathways

This section looks into the findings of the transition phase of the backcasting process, which was aimed to design policy pathways to reach the alternative transport future. A participatory approach to backcasting was adopted, using semi-structured interviews to engage participants. This approach is similar to other backcasting studies (Banister et al., 2013; Zimmermann et al., 2012a) which have used two-way interactions between the researcher and stakeholder to explore plausible pathways for sustainable transport futures. The innovation in the methodological approach used for this study lies in the application of the Theory of Social Practice to guide the policy development process.

The literature covering the Theory of Social Practice has often discussed the challenge that lies in the application of practice theory to policy interventions (Keller et al., 2016; Kent, 2022; Kok et al., 2011). Such approaches have often been criticized as being difficult to operationalise in policy development and needing further research before developed into tangible interventions (Maller et al., 2014; Spurling et al., 2013). The result of this research demonstrate how the combination of practice-oriented policy development with a backcasting approach can start addressing the challenges in constructing sustainable transport policies.

The results reveal potential pathways for three alternative transport futures. Interventions were designed to reflect the practice-oriented futures and the policy design process was structured to reflect changes in the elements of mobility practices and influences in wider social practices of everyday life. Interventions included those which are focused on material aspects such as the re-design of bus network and improved infrastructure for active modes of travel. They also include policies which address the skills which are required for the transition towards more sustainable mobility. These include policies which introduce bikeability programmes and information on cycle and walking routes. Other interventions address the meanings tied to mobility practices and include measures such as awareness campaigns on the benefits of walking and educational programmes on road use to improve safety on the roads. Other measures included in the policy pathways target the intersection between mobility and other practices such as working and shopping. For example, the introduction of flexi-hours aims to reduce the dependency on the car for commuting. The provision of bus to retail, incentives for online shopping and development of supermarkets within town centers are all measures which aim to decrease the use of the car for the purpose of shopping.

The policy interventions resultant from this research, are in some aspects similar to other policy interventions developed in similar backcasting studies (Banister et al., 2013; Soria-Lara et al., 2017a; Tuominen et al., 2014). However, the pathways created in this study go beyond the provision of material elements such as walking infrastructure to promote active travel or the re-design of urban form to support sustainable transport. For example, the practice-based policy exercise recognises that engaging in walking not only necessitates the availability of walking paths, but also the information necessary to help individuals navigate their way to their destination. Transport futures for this study factor in the meanings which are also important for participants to shift to low-carbon forms of travel for example by suggesting ways to make roads safer for walking and cycling.

The involvement of citizens into the policy planning process has resulted in the creation of a more democratic way of establishing policy pathways, rather than the traditional deliberative process involving a narrow group of experts (Booth et al., 2001; Doyle et al., 2013). The workshop setting employed in the research as a means to engage citizens was important to create a space where members of the public could interact and express their ideas on transport. This has facilitated the co-production of policy pathways which have the potential of being more acceptable than those solely based on expert views.

## 9.2 Policy implications and recommendations

This section will discuss the implications of the study results on Malta's transport policy. Based on the findings from this research and those of the current literature on transport climate policy, policy recommendations are proposed. These recommendations are aimed to provide insight into what measures can be implemented to help in the transition towards more sustainable transport in Malta.

### 9.2.1 Understanding the complexity of mobility practices

The result of this study was useful to provide insights into the complexity of mobility practices which complexity has often been overlooked by the individualistic and rational approaches to transport research (Carrasco et al., 2014). Transport practices and transport systems are known to engender complexity (Kent, 2022; Watson, 2012). The Theory of Social Practice provides a framework which helps to reveal and make sense of such complexity and facilitate its understanding. It allows appreciation of the interdependencies between sets of elements and interaction of travel with everyday life. The three elemental model proposed by Shove et al. (2012) is useful as it enables explorations and demonstrations of the complexity of a practice. The disaggregation of mobility practices into the three elements allows for an enhanced vision of mobility practices, which can provide a fuller set of foot-holds for influence (Spotswood et al., 2015).

Transport policy in Malta could start to draw insights which focus on the complexity of transport policies. In terms of reshaping mobility practices, the recognition of the absence of elements of sustainable transport practices can serve as starting point in devising policies to address sustainable mobility. The findings of this study suggest that transport practices are a result of the intertwined dynamics between different elements of practices. Policy which targets the elements of transport practices separately might fail to bring about the required transitions in transport. While material aspects of transport practices are important, transport policy should go beyond purely targeting material elements and start addressing how everyday mobility is also shaped by dynamics such as social norms and meanings, and limited by existence of competencies and skills (Franziska Meinherz et al., 2020). A focus on intertwined elements comprising a practice can provide the necessarily tools for change in transport (Watson, 2012).

For example, while the provision of cycling infrastructure is important for a shift from car-based travel to cycling, the introduction of a cycling mentoring programme can help recrafting of the elements of cycling as a practice to emphasise the material objects and skills required to cycle (Spurling et al., 2014). The introduction of cycle proficiency programmes in schools (Mackett, 2013), is one way to address the lack of competencies required to take up cycling. These programmes which include training in safe and effective cycling techniques, have been shown effective in the promotion of this active form of travel (Pucher et al., 2008b). The results of our research also suggest that the transition to cycling can be supported through the provision of information on available cycle paths which help cyclists navigate to their destination. This information may be made available through detailed maps of the available cycling facilities and internet-based bike route planning that assist cyclists in choosing the route that best serves their needs (Pucher et al., 2008a). The investment in dedicated cycling infrastructure, training motorists to be aware of cyclists on the road and avoid endangering them, together with traffic calming measures (Pucher et al., 2008b) are policy initiatives that can help reduce the negative meaning around road safety and cycling and hence promote this form of practice.

Similarly, this research provides some useful insights into policy options that might enable more individuals to engage in walking as a form of travel. As in the case of cycling, the results highlight that Malta still lacks a good infrastructure that facilitates walking. Improvements of walking paths and walking routes could potentially lead to more individuals taking up walking. Analyzing walking from a social practice perspective has also shown that one of the competencies required for an individual to engage in this practice is the ability to calculate distances and estimate the time required to reach the destination. The implementation of wayfinding strategies can help bridge the gap in the competencies required for individuals to engage in this practice.  Evidence from such initiatives in other countries, such as the Legible London project in the UK, suggest that a wayfinding system can provide users with the necessarily information to make decisions about walking and thus encourage this form of travel (Vandenberg et al., 2016). Furthermore, the results have clearly indicated that practitioners of walking associate this practice with positive meanings, such as being relaxing and as a benefit to their health. From such findings, it may be suggested that walking in Malta can be promoted through awareness campaigns which are based on the experiences of the practitioners who have already engaged in this form of mobility (Cañas et al., 2021).

Traveling by bus in Malta requires a unique set of elements. Interventions to provide for these elements can include a dense network of bus provision with multiple routes. Such a provision would allow easy access to destinations or sites of activities. High frequency services, reliable and regular bus facilities would mean timely arrival and less-time wasted waiting for the bus (Paulley et al., 2006), thus allowing for the bus to compete with the high efficiency of the car. The results of this research show that bus cleanliness and comfort (Foote, 2004) are other important material elements that should be considered when aiming to increase the share of users traveling with the bus. Further to these material elements, policy should focus on knowledge on how to use bus routes to achieve timely arrival (competencies), and help users understand how the time on the bus can be transformed into productive time (meanings) (Lyons et al., 2005; Santos et al., 2013).

### 9.2.2 Addressing transport issues through non-transport policies

Another recommendation which can be made for transport policy in Malta is one which relates to the incorporation of understandings of practice as complexes when designing interventions to shift transport towards more sustainable forms. The results presented in this study, in Chapter 5, have been important to demonstrate the influence of different social practices on the demand for travel. These findings suggest how policy can shift away from a focus which takes into account only transport and start looking at other non-transport foci for intervention.

This research has shown how some social practices such as parenting, shopping and doing business bundle more strongly with the use of private car than other forms of social practices.

These results are concordant with other social practices-based studies which have investigated transport and mobility. For example, Sersli et al., (2020) found that the practice of taking care of children was difficult to perform with the practice of cycling. Other literature has shown how practices including escorting of children, shopping and travel with pets are car-intensive forms of practices (Mattioli et al., 2017; Mattioli et al., 2016). Whilst others commentate on how the engagement in social practices such as working, shopping and parenting influence the choice of travel mode (Cass et al., 2016). These findings highlight the importance of understanding both transport and activities or practices facilitated by transport when trying to uncover transport decision making (Birtchnell, 2012; Kent, 2022; Watson, 2012).

Understanding transport as a system which complexes or bundles with other complex social systems and how transport is embedded within modern lifestyles allows a clearer picture of sites where interventions may contribute to a shift to more sustainable mobility and which are still lacking from traditional transport policy. Through the concept of bundles and complexes, insights from practice theory, such as those from this study can be employed to study the motives behind travel choices. Such thinking allows a wider range of interventions for a specific aim (Kent, 2022). The identification of travel intensive practices can be targeted with specific interventions that shape travel patterns around those practices (Mattioli et al., 2016).

For example, this research has shown that intersection between schooling practices and working routines of parents has an important effect on the mode of travel and could provide a new focus for policy action. Flexible start and end time at the work place coupled with teleworking facilities have the potential of reducing the time constraints parents face when trying to coordinate travel between different activities, and thus allow more time for active types of travel such as walking to school. After-school programmes for children could also help alleviate the time constraints that parents experience while trying to fit work and parenting responsibilities.

At the work place, interventions inspired from a Theory of Social Practice perspective can also help shape practices to allow for more low-carbon forms of travel. Changes to the core working hours, flexible working times and teleworking are all options that eliminate the limited time for movement between sites of practices thus enabling bus or bicycle commuting (Van Lier et al., 2014). Recent developments following pandemic lockdowns has provided ample opportunity to test some of these measures (Campisi et al., 2022; de Palma et al., 2022; Ton et al., 2022). Encouraging the provision of retail and other facilities close to the workplace may also encourage the use of active modes of travel between different sites of practice. Another site for intervention from a social practices lens which could contribute to lower the dependence on high-carbon forms of mobility is shopping. Our research has shown that shopping at large-peripheral supermarkets encourages car use. One way in which policy can intervene is by encouraging provision of retail close to sites of other practices such as local shops and shops close to workplaces (Barton et al., 2012). Policy can also aim to encourage online shopping thus reducing the car-dependent shopping trips (Rosqvist et al., 2016) or provide bus services to large retail outlets.

### 9.2.3 Adopting long-term visioning in transport policy making

As demonstrated in the literature review in Chapter 2, the backcasting process is a useful approach to treat complex problems when the business-as-usual is no longer appropriate and radical changes are required to reach sustainability goals (Banister et al., 2000; Hickman et al., 2011). One advantage of this process is that it takes a long-term approach, that allows freedom from the constraints of the current trends and conditions, and the need for solving the obstructions caused by them (Heinonen et al., 2012).

This study has shown the importance of long-term planning if alternative futures to the unsustainable business-as-usual are to be sought. Structural changes and shifts in mobility practices require a significant time to be implemented. Long-term planning (25 - 30 years) is important in transport policy making to enable existing trends that are strongly amalgamated in our society to be re-orientated (Soria-Lara et al., 2017b). In addition, decisions made in transport tend to have long term effects and much of the infrastructure built today will be in use for a long time (Tuominen et al., 2014). Despite the importance of this long-term planning, the approach is still lacking from the national transport planning policy. Transport policy in Malta has been very weak with much of the policy being led by the predict-and-provide philosophy in favour of private-car use (Attard, 2005). In recent years, the National Transport Strategy published in 2016 (Transport Malta, 2016a) looks at strategic goals for transport up to the year 2050. However, this only proposes measures and policies in the short and medium term. The traditional means of transport policy making which is based on forecasting the future based on past trends (the predict-and-provide approach) may have been successful in the short term and have worked in the past. However, when considering the case of sustainable transport and climate change there is a necessity to introduce long-term and more strategic planning. This type of planning enables policies which require a long implementation time to be effective and impacts to make the required shifts.

Long-term visioning however was observed to be a challenge for the stakeholders during the visioning workshop. Most of the participants were unfamiliar with long-term thinking and projections of visions over the long term horizon. In the study presented in this research, this lack of long-term visioning was mitigated by encouraging and guiding the participants to think about long term futures by providing the participants with examples of other transport projects which utilised long term visioning. In the real-life policy design, a solution to the lack of long-term visioning can be addressed by providing policy-makers with training to help them visualise options in different temporal horizons (Soria-Lara et al., 2017b).

### 9.2.4 Incorporating participatory approaches to transport planning

The results of the visioning exercise have demonstrated how the inclusion of participatory approaches fosters dialogue amongst different participants and brings together different perspectives. These results show the effectiveness that participatory approaches can add to planning processes. Experts have been traditionally used as the main source of backcasting processes (Banister and Hickman, 2013; Mattila and Antikainen, 2011; Shiftan et al., 2003). Integrating multiple perspectives during the backcasting process has a number of advantages. Multiple perspectives can produce more radical futures compared to methods which are based on the input of experts (Wagnel, 2011). Including a mix of perspectives such as members of the public, practitioners and decision-makers and researchers is critical for the outcomes of the backcating exercise. The type of stakeholders involved in backcasting is critical and the choice of participants can bias the results. For example, similar studies have found that the participation of young individuals (between 14 and 35 years old), produced more radical futures than scenarios which were based on the input of older participants (Tuominen et al., 2014). Including young individuals thus is important for more disruptive thinking in backcasting. However, it is also important to ensure that the views created are also realistic and a combination of different generations of participants and expert and non-expert is desirable.

The inclusion of a wide range of stakeholders not only experts, produces a more democratic process rather than the more deliberative process involving a single group of experts. This form of transport planning is also known to be essential for bridging the gap between researchers and policy makers in transport policy (Banister et al., 2013). The participation of different stakeholders in strategic planning helps to reduce the gap between scientific knowledge for policy support and actual implementation of policy measures (Tuominen et al., 2014).

Further to bridging the implementation gap, the active involvement and commitment of all relevant stakeholders is needed for a transition towards a more sustainable mobility where the scale of change required cannot be realised by a single actor. Current national transport policies could increasingly acknowledge the benefits and adopt participatory methods for policy design. Different and wide-ranging sets of stakeholders can be engaged in the process of developing ideas about sustainable mobility practices. A number of tools are available for engagement of participants in planning processes including workshops, semi-structured interviews and Delphi-surveys (Wangel, 2011a). The use of workshops for bringing together different stakeholders was found to work well in this study.

### 9.2.6 Acknowledging the role of the public in transport planning

Public participation is an important part of transport planning (Le Pira et al., 2016). This backcasting exercise has demonstrated how the inclusion of members of the public in policy design can further enhance the process and yield policies which are easier to implement and are more acceptable. The important role that the public plays is also acknowledged by the European Union transport policy for example in the adoption of Sustainable Urban Mobility Plans (Wefering, 2013). Public participation should be an integral part of transport planning process in Malta. Public participation can promote local solutions to the transport challenges faced and uncover knowledge about the socio-cultural systems which were not evident previously. Communication between the public and other stakeholders in the planning process can be a success for fostering innovative ideas and make the planning process a more democratic one. Engaging the public in deliberative discussions about transport and sustainable mobility also has the potential of changing the citizens' level of knowledge and support about transport policies (Quick et al., 2015).

### 9.2.7 Developing innovative policy instruments

The current national transport policies are clearly not appropriate to significantly reduce the emissions from the transport sector and make a significant contribution to the achievement of the climate change mitigation targets, as was discussed in Chapter 2. Innovative and more radical policy instruments are required to bring about the required systematic change and shift towards sustainable mobility. The results of the transition phase of the backcasting study was important to demonstrate how insights from new perspectives such as social sciences can provide new footholds for innovations in transport policy. This does not mean that polices informed by other approaches such as technological innovation and behavioural change are not important (Schwanen et al., 2011). However, there is a need to shift the focus from polices which only target infrastructure or individual choice and include more radical policies which target socio-structural factors that have an influence on travel if carbon reduction targets are to be achieved (Cass et al., 2016).

### 9.2.8 Adopting an integrated approach to sustainable transport policy

The results of the visioning phase and the assessment of the alternative transport futures presented in this study have demonstrated how significant $CO_2$ emission reductions are very difficult to achieve. The alternative transport futures presented in this study reveal how there is no singular or “silver bullet” strategy for making deep cuts in transport emissions (McCollum et al., 2009). Technological innovation alone or strategies based solely on voluntary behavioral change are not enough for meeting the ambitious $CO_2$ emission reduction by 2050. If substantial emission reductions are to be made, an integrated policy approach which encompasses diversity of policy options is required. A diverse portfolio approach which includes a mix of policy options has a greater potential of significantly reducing GHG emissions from the sector. Achieving deep reductions will require a mix of strategies that cover a range of policy options that together can make a significant change in the levels of transport emissions (Robin Hickman et al., 2010; Tuominen et al., 2014).

## 9.3 Strengths and limitations of the research

This section focuses on the key strengths and limitations of the research. It discusses the approaches that strengthen the research, the major limitations encountered and explains how these were mitigated, and the implications for this research.

### 9.3.1 Strengths of the research

The research is based on an innovative methodology for developing alternative policy pathways for a more sustainable transport in Malta in 2050. This approach is based on the backcasting framework and integrates this with the Theory of Social Practice. This methodological approach presents advantages over the more conventional approaches of transport policy making. The use of social practices in combination with backcasting allows for a greater reflection of the social and cultural context when considering transport policy and planning.

The examination of the materials, the necessary competencies, and societally-valued meanings that together constitute and define the mobility practices provides more opportunities for influence when compared to other approaches that target individual behaviour. In addition, rather than viewing mobility as a practice on its own, as is done in other approaches to modal shift, this approach allows for intervention in the wider system of practices which produces the need for mobility. The results of this research demonstrates how innovative and emerging theories, such as the Theory of Social Practice (Schwanen et al., 2011), can be combined with existing transport planning tools to develop more radical transport policy options.

### 9.3.2 Limitations of the research

Despite the attention given to the details of the study approaches, to ensure accurate results are produced which, in turn can be translated into usable forms of data that can provide new insights on planning for sustainable transport, some limitations of the study are acknowledged.

The first limitation is related to the use of an on-line survey methodology as a tool to collect data on the current situation of transport in Malta and set the baseline for the study.  While online surveys offer a number of advantages over other research methods especially where research costs are a constraint and timeliness are important, they do not come without their limitations. One major limitation of online surveys is the lack of control on the selection of the participants. Sample representativeness is one of the issues in online surveys and this type of data collection method may introduce bias in the data collected by excluding sections of the population. For example, online surveys, exclude participants who do not have excess to the internet, which may influence the representativeness of the sampled population. Despite this limitation, the concern over sample representativeness is not of great concern when non-probability sampling (such as in the case of the present research) is sought (Wright, 2005).

The second limitation is tied to the long-term visioning aspect of the backcasting study. The main aim for adopting a backcasting approach is to break the current trends in situations hence, the backcasting is usually based on visions that are 15–30 years in the future. However, it was noted that during the visioning workshop many of the participants found this long-term visioning a difficult process to conceptualise when asked to envision transport futures. To help overcome this difficulty during the visioning workshop, the participants were presented with examples from other future visioning projects. Furthermore, during the duration of the visioning process, the research team encouraged and reminded the participants to think in terms of a long-time horizon.

Thirdly, it was noted that most of the stakeholders were unfamiliar with the Theory of Social Practice. The introductory session of the visioning workshop included a presentation on social practice intended to familiarise the participants with the concepts of this theory. However, the research team still felt it was difficult for the participants to understand this theoretical framework in such a short time and use it effectively as the basis for creating future visions. The same issue was observed in other studies where the Theory of Social Practice guided the visioning of alternative futures (Doyle et al., 2013). It is therefore suggested that greater emphasis is placed on ensuring participants have a better understanding of the theory before engaging in the participatory activity. A solution could be an introductory session describing the elements of the theory, including examples of how it can be applied to sustainability transitions.

Another limitation of the visioning phase of the backcasting process is the limiting capacity of the methods used in generating disruptive futures which are significantly different from the business-as-usual scenario. The development of future visions in this research was based on the use of workshop approach which is known to be more advantageous over other consensus seeking methods (such as Delphi surveys and questionnaires) in generating disruptive visions

(Banister and Hickman, 2013; 2017). Consensus-based approach limit the capacity of the visioning exercise to incorporate outliers and divergent views about the future. However, even with a workshop approach, the obtained visions may still be similar to the business-as-usual scenario. With this type of approach, there is a chance that only the most common ideas and most frequent thoughts remain in the final visions and limit the inclusion of more disruptive thinking (Soria-Lara and Banister, 2018a). The selection of participants in vision development is also a crucial aspect for creating more disruptive visions. For example, experts and stakeholders are more strongly influenced by their professional domains and their ideas are biased by their linear visualisation of the future. Involving a range of different participants and incorporating experts and non-experts provides better chance of producing "out-of-the-box" ideas about the future (Tuominen et al. 2014). In addition, the construction of multiple long-term visions rather than single future visions provides more space for exploring more divergent futures Tapio, 2003; Tuominen et al., 2014).

The future visions generated for this study focus on technological improvement in mass transport (scenario 1), redesign of urban forms and reduced travel distances (scenario 2) and promotion of active travel and green spaces (scenario 3). These scenarios may seem not very disruptive and the results of the visioning exercise similar to linear forecasting type visioning, a limitation of the methods. However, in this study the focus for the design of alternative future visions was based on mobility practices. The visions generated are different from the business-as-usual scenario and present alternatives to the current transport trends. The end results incorporate innovations in the different elements of mobility practices which would not have otherwise been thought of more conventional methods of visioning. Future studies could explore different methods of visioning which can generate more disruptive visions. This could include a visioning process based on the participation of young individuals who will be adults of tomorrow and can think more about more original visions (Tuominen et al., 2014). The use of wild-cards during the visioning process may also contribute to more radical future visions (Soria-Lara et al., 2021).

The workshop organised with the members of the public served to demonstrate how the involvement of citizens led to many creative ideas and proposals for improving the policy pathways for the alternative transport futures. This may suggest that future backcasting processes may benefit from the involvement of citizens in the earlier phases of the process such as the visioning phase (Tori et al., 2022; Uwasu et al., 2020). Earlier and higher level of citizen engagement would have enabled a higher level of normative visioning of transport futures and input of the first-hand perspectives about transport (Keseru et al., 2021). This backcasting study could have also benefitted from views from younger people – a group of citizens who can provide fresh ideas and who will be the decision makers in the future (Tuominen et al., 2014; Varho et al., 2013).

As discussed in section 9.1.3, modelling of the impact of the alternative futures on the carbon emissions brings with it a number of uncertainties. While attention was taken to use accurate sources of data, modelling in the long term is highly uncertain. One of the major difficulties encountered during the modelling exercise, was related to the collation of secondary sources of data to populate the parameters required by the model. This data collation necessitated robust and time consuming literature search for the identification of reliable data sources which could serve as an input to the emission calculation. The model results have also been validated against similar studies. However, caution must be taken when interpreting these results taking into account uncertainty. In this backcasting study, the alternative future scenarios have been assessed for their potential for reducing emissions. The research could have also further benefitted from the assessment of the policy pathways for their social, financial and environmental impacts (Hickman et al., 2012; Julio A. Soria-Lara et al., 2018). It would also be useful to further assess the interactions between different interventions and the effect of any synergies between different policies.

This research was based on the unique case study of Malta, which represents a good backdrop to test the participatory backcasting framework for developing low-carbon transport policies in a context where car-dependency is high and transition to sustainable mobility has so far been difficult to achieve. Nonetheless, the results presented in this study remain unique to the case-study. Other contexts may benefit from the demonstration of the methodological framework, however the results of this study remain non-generalizable to other contexts which may require different sets of options and policy pathways.

## 9.4 Conclusion

This chapter focused on the discussion of the findings from the different phases of the backcasting process. These findings were discussed in the context of the body of knowledge on this topic as presented in literature. The first section of the discussion was focused on the results of the current mobility practices in Malta, visions for alternative futures and their suitability and pathways to reach these desirable visions. The second section discussed the implications for policy and recommendations for transport policy in Malta. The strengths and limitations of the current study were discussed in the last section of this chapter.

The next chapter, Chapter 10, concludes this research. It summarises the main findings, describes the knowledge contribution of this research, and proposes future work which may be perused based on the outcomes of this research.

# CHAPTER 10: CONCLUSION

This chapter provides the conclusions to this study. It provides a summary of the main findings of the research and reflects on the conclusions of the results. Section 10.1, summarises the key findings of the study in the context of the objectives, research questions and the aim of the thesis. The main lessons learnt are summarised in Section 10.2 and the contributions of the research to knowledge are then discussed in Section 10.3. The final section, 10.4, provides suggestions for future research which might build on the knowledge of this research.

## 10.1 Summary of findings

The overall aim of the research was to ***analyse how a transition to low-carbon mobility can help to achieve climate change mitigation targets***. To test the aim of the research, a case study approach was adopted which focused on Malta, a context with high dependence on the private car and with specific characteristics of small islands that require tailor-made and sophisticated approaches to transport planning and low-carbon mobility. The research aim was further subdivided into research objectives (Objectives 1-3) and specific research questions (RQ 1-4).

### 10.1.1 Research Objective 1

The first research objective sought *to* ***identify key approaches in transport research dealing with climate change mitigation and frame a suitable approach for a study in Malta.*** This research objective was met through the literature review which was presented in Chapter 2. The main and current approaches in transport research dealing with climate change mitigation were discussed. This included a discussion on technological change, (neo-classical) economics, geography, psychology and behavioural and sociology and how each of these views contribute to the understating of transport and its role in the transition towards low-carbon societies. The literature review served to highlight the variability within academic research dealing with climate change mitigation in transport.

Following an overview of these approaches, some important conclusions could be made from the review of the available literature. In particular, current transport research shows a strong emphasis on the role that technology plays in reducing transport emissions, how economic instruments and land use planning can influence travel and how behaviour of individuals can be altered through information campaigns and social marketing. These approaches, offer a valuable contribution towards the understanding of the issues surrounding climate change and transport. However, the review served also to show how these contemporary approaches have the tendency to overlook some important facets of transport that are critical for the understating of the transition to low-carbon forms of transport.

Amongst some of the facets that transport research is not addressing when it comes to climate change mitigation, there are the societal embedding of transitions to sustainable forms of transport. Further analysis of the available literature revealed new research that is emerging, and which has the potential of confronting the uncertainties and the complexities of transport decarbonisation. One of the emerging research traditions that can provide alternative insights and help moderate the limitations of the contemporary transport research approaches is the Theory of Social Practice.

The review of the literature highlighted a gap in research, and how perspectives from the Theory of Social Practice can help to contribute to a deeper understanding of mode choice and the barriers for transition to low-carbon forms of travel. The conclusions help to place the current study in context and identify a suitable approach for analysing the transition to low-carbon mobility. Based on these conclusions, this research sought to develop a framework using the Theory of Social Practice to provide new and alternative insights into the decarbonisation of the transport sector.

### 10.1.2 Research Objective 2

The second research objective aimed *to* ***identify the current mobility practices and how changes in the current practices can contribute towards more sustainable mobility.*** This research objective was addressed through two specific research questions, and the results for these research questions were presented in Chapter 5 and Chapter 6. The first research question addressed the current state of mobility practices in the case study context. The second research question explored how these unsustainable practices can be transformed to more sustainable forms of mobility in the future.

***Research Question 1: What are the current CO2 emissions from transport and what are the current types of mobility practices in Malta?***

The first part of the research question was addressed in Chapter 1, section 1.3.3 which provided an overview of the current levels of $CO_2$ emissions in Malta vis-à-vis the climate change mitigation targets. In addition, this section was important to outline the significant contribution of the transport sector to these emissions. Such an understanding was important to highlight the potential of the transport sector in limiting emissions and contributing to achieving the climate change mitigation targets in Malta. The research shows that the current approaches (Transport Malta, 2016a) in Malta are unlikely to lead to significant transport $CO_2$ reduction.

Chapter 5 then further explored the context of the case study through the analysis of the constituent elements of the current mobility practices and an investigation into which other social practices bundle or influence mobility. The results of Chapter 5 were based on the results of a representative survey (n=400) amongst the population in the case study and semi-structured interviews (n=20) with a range of individuals having different lifestyles and showing preference towards different modes of mobility. The results were important to demonstrate that the car is the preferred mode of travel amongst the population, while other modes such as using the bus, cycling and walking are less popular with the participants. A number of social practices were found to form bundles with mobility practices. Social practices which include working, education, shopping, shopping for food, leisure activities and engagement in sport activities are dependent on mobility. The findings also demonstrated that the modal choice is influenced by the type of activity at destination.

The fixed timings for work and school, parental responsibilities, shopping and other activities were found to significantly shape the mode choice. In agreement with previous research, work was found to have a substantial impact on the recruitment to specific mobility practices over others. Parenting has important effects on travel, and parents who often need to coordinate their activities and tend to the travelling needs of their children tend to prefer to make their trips using the car. The practice of shopping, especially when grocery shopping at large peripheral supermarkets, was also shown to push individuals towards car use, which enables them to reach destinations that otherwise are difficult to get to and also help them in transporting their purchases home. The use of the social practice framework helps to understand the embeddedness and 'fixity' of car usage in Malta, and the complexity of the policy response required. Infrastructure improvement is critical, but there also meaning and competency dimensions which cannot be overlooked. In Malta, it is very important to move away from the high car dependency, but this will involve quite complex future-orientated policy packages, beyond existing practices or single infrastructure projects, which is different to previous work in this area which tends to focus on current practices (Shove and Walker, 2007; Spotswood, 2015).

***Research Question 2: How can the current mobility practices be reconfigured to more sustainable forms?***

In Chapter 6, alternative transport future scenarios for Malta were developed. In these alternative scenarios, the elements of the current and unsustainable mobility practices are configured into more sustainable practices. In these scenarios, other social practices that influence modal choice have also changed allowing for better use of low-carbon forms of mobility. These alternative future scenarios were the result of a practice-based participatory visioning workshop. The results presented in Chapter 5, on the current mobility practices were used as a starting point for the development of alternative transport visions. Stakeholders participating in the visioning exercise, discussed changes to the constituent elements of the current mobility practices.

The participation of different stakeholders with different backgrounds and a range of skills and expertise was a fundamental aspect of the visioning process. The visioning process resulted in the development of four transport future scenarios. One transport future depicts the business as usual scenario while the other three scenarios namely; *High Tech Mobility*, *Local Active Mobility* and *Green Active Travel* are more sustainable alternatives. The innovation in the scenarios developed in this study comes from the additional perspectives which emerge when applying the Theory of Social Practice. In contrast to other scenario studies, the focus of the scenarios generated in this research go beyond material elements such as building new infrastructure or introducing cleaner technologies. Instead, the alternative scenarios developed in this study encompass all elements of mobility practices and incorporate both the skills which individuals need to transition to low-carbon forms of mobility and target the meanings which individuals associate with travelling.

### 10.1.3 Research Objective 3

The third research objective; ***to determine the impacts of transitions towards sustainable mobility and identify policy pathways*** was addressed with two research questions (Research Questions 3 and 4). The results for these research questions were presented in Chapters 7 and

8. The first of these two research questions looks at the $CO_2$ reduction potential of the three alternative future scenarios. The second research questions looked at the policy pathways which are necessary to achieve the alternative future scenarios.

***Research Question 3: What are the likely impacts of such reconfigurations on $CO_2$ emissions from transport?***

In Chapter 7 a transport modelling approach was used to assess the impact of the alternative future scenarios on the emissions of $CO_2$ from transport. The ForFITS Model developed by the United Nations Economic Commission for Europe (UNECE), was used to estimate emission levels under each of the alternative scenarios. The modelling exercise proved a useful tool for the evaluation of the potential of the alternative future scenarios in achieving the desired emission reduction targets for Malta.

The results presented in Chapter 7 have shown how the target of 80% reduction in $CO_2$ emissions from the base-year was difficult to achieve under all three alternative future scenarios. Alternative transport Scenario 2, *Local Active Mobility*, shows highest percentage emission reduction from the baseline and thus offers the highest mitigation potential. In this scenario, carbon emission reduction is achieved through reduction of travel distances and shift from car-based travel. Alternative transport future 3- *Green and Active Travel,* have lower emission reduction potential than the alternative Scenario 2. In this scenario prioritisation of active modes of travel are at the centre of the lower levels of $CO_2$. Alternative scenario 1 – *High Tech Mobility* – presents lowest potential for emission reduction. In this scenario emissions are reduced only through a shift to mass transport and technological improvements that allow for high levels of activity but with low-carbon emissions.

The results of the modelling exercise carried out as part of this backcasting study show that policy measures with a focus on one aspect of the transport system such as technology or modal shift are often not enough to meet the mitigation targets. Meeting the GHG reduction target may be more feasible with the adoption of policy mixes which incorporate both modal shift and improvement in technology.

***Research Question 4: What policy implementation pathways can be developed to meet the sustainable mobility practices?***

Chapter 8 presented the results of the participatory process which was based on the engagement of stakeholders and citizens in the design of policy pathways which would lead to the alternative future scenarios in 2050. An on-line survey and interviews were used as the primarily method of engaging stakeholders in the process of identifying suitable policies to deliver sustainable transport futures together with their implementation timeframes. A workshop was used to incorporate the perspectives of citizens in the policy design process.

The results of this process are in the form of three sets of policy pathways, one for each of the three alternative future scenarios. These policy pathways are different from those found in similar backcasting studies as they include once again the perspective of the Theory of Social Practice. In contrast to other studies, policies identified in this study take into account the influence of inter-related set of elements (materials, competencies and meanings) that constitute social practices. Policies resultant from this study further target competencies, for example the ability to use a bicycle, and meanings, such as comfort and safety, which are critical in shaping the travel choices.

## 10.2 Lesson learnt

The results of this study were discussed, and a number of points were drawn on the methodological lessons resulting from the research. These lessons can be used for a better understanding of current and unsustainable mobility practices and the type of interventions that would enable the shift to more sustainable mobility. Based on the outcomes of this research, a set of policy recommendations were suggested for sustainable transport future for the case study of Malta:

1. The transition to more sustainable transport future can be facilitated by an understanding of the complexity of mobility practices. The appreciation of the interdependencies between set of elements of mobility practices and interaction of travel with everyday life can illuminate areas of interventions which were otherwise not evident with conventional approaches to policy making.
2. A crucial point which emerged from the results of the research showed how a shift in focus on transport issues through non-transport policies, such as designing

interventions which target practices of shopping, parenting and working can start addressing the shortcomings of current transport policies.

3. Adopting long-term visioning in transport policy making to allow enough time for significant structural changes and shifts in mobility practices is necessary.
4. Incorporating participatory approaches to transport planning and including different stakeholders has the benefit of bringing together different perspectives, making the process more democratic and policies more implementable.
5. Public participation is an important part of transport planning, where the inclusion of members of the public in policy design can further enhance the process and yield policies which are easier to implement and are more acceptable.
6. A more significant contribution from the transport sector in terms of emission reduction is needed if the climate change mitigation targets for Malta are to be met. Innovative and more radical policy instruments are required to bring about the required systematic change and shift towards sustainable mobility.
7. Adopting an integrated approach to sustainable transport policy which includes a mix of policy options has a greater potential of significantly reducing $CO_2$ emissions from the sector.

## 10.3 Contributions to knowledge

Whilst acknowledging that this study does not come without its limitations and the conclusions from a single case study cannot be generalisable to other contexts, this research provides a number of valuable contributions to knowledge. This section will highlight these contributions to the body of literature around decarbonisation of transport and transitions to sustainable mobility.

This research used the case study of Malta to understand mobility practices, how these are embedded in daily routines and which policy interventions can be effective in bringing about the required shift in road transport and travel choices. The results of this study are not meant to provide data which can be extrapolated directly to other contexts. However, the results of this study provide valuable insights into the challenges of transitioning to low-carbon transport especially in contexts of high car dependence and small island states. The results of this study demonstrate that while some findings are similar to other literature, other aspects are more unique to the case of Malta. For example, while the influence of social practices on mobility may be similar to other contexts, some of competencies that are required for shifting to low-carbon mobility and the valued meanings around mobility are particular for the case under study. The results further demonstrated how the setting of the Maltese islands, with its limited geographical space and unique cultural characteristics requires distinct policy options which can effectively influence the current transport situation. These findings highlight how decarbonisation of transport is not a one-size fits all solution but requires tailored-made solutions which are specific to the geographical context.

This research has made an important contribution to widening the knowledge on the Theory of Social Practice by applying the concept of social practice in the transport field and using it in relation to scenario analysis. Despite the development of the Theory of Social Practice in academic literature, there are still gaps when it comes to the application of this theory to policy and practice. The results demonstrate the potential of practice theory in informing policy makers seeking to induce societal transitions to sustainable mobility. Through the combination of the theoretical concepts with more established methodological frameworks, this research demonstrated how the Theory of Social Practice can find practical applications in transport policy making.

The study also makes an important contribution to the current knowledge on the available tools in transport planning which are useful for addressing long term sustainability problems. Backcasting is one such framework which has found application for the treatment of climate change issues in transport policy making. The findings of this research were useful to show how transport planning tools can benefit from the integration of new and emerging theoretical concepts dealing with sustainability transitions. The use of concepts from the Theory of Social Practice in combination with backcasting has the advantage of allowing for a greater reflection of the social and cultural context when considering transport policy and planning. The innovation that the Theory of Social Practice approach can bring to transport policy making is exemplified by the scenario types developed in this study. The backcasting stage was done in a participatory manner, allowing different viewpoints to be incorporated. It also incorporated the material, meaning and competency dimensions from the social practice framework. This was innovative and was required to help understand the complexity of the required policy packages. Particularly the research was important to understand that meanings are likely to be very important in the Malta context. The narratives created from the visioning consider the reconfiguration of all three elements (materials, competencies, and meanings) of the mobility practices. A practice-oriented approach to transport visioning also suggests that sustainable transport futures need to include changes not only in transport but in other non-transport practices which have implications for mobility demand and low carbon travel.

Finally, the Malta context is innovative, as it illustrates what might be required in a very car dependent, Mediterranean island context. Potentially cycling and walking can become much more important, but this will be part of a broader package of measures, including new forms of public transport and cleaner vehicles, with a much stronger shared usage.

## 10.4 Future Work

The preceding sections (10.3 and 10.4) have highlighted the significance of the study to the Maltese transport planning and the contributions to the wider knowledge base on the decarbonisation of the transport sector. Nonetheless, the findings of this research may serve as an opportunity for initiating future work.

The practice-based participatory backcasting framework explored in this research, was aimed at testing how insights from the Theory of Social Practice can illuminate interventions in policies which are more radical than the current approaches and have a higher potential in bringing about the required shift in personal transport. The case study of Malta proved that insights from the Theory of Social Practice can indeed contribute to policies in transport which are more inclusive and are more focused on systemic change. This study serves as a starting point for testing the application of this theoretical concept for future studies. There is opportunity for future work to test the practice-based backcasting framework in other geographical contexts. The results under different contexts and setting can help to further prove the usefulness of the approach.

Future research in transport backcasting could also focus on how different actors shape the backcasting process. More case studies which can contribute to the evaluation of how the participation of different actors determine the types of future narratives, the degree of disruption from the business-as-usual scenario and the influence of the different perspectives on the designed policy pathways.

Future transport research with a focus on shifting to low-carbon mobility in Malta could also benefit from other perspectives in social sciences. For example, transport research in Malta could focus on other transition frameworks for a better understanding of the barriers towards sustainable mobility. Perspective from the social sciences can produce a valid contribution to the knowledge on low-carbon mobility by providing an integrated and systemic insights on socio-technical changes. Such perspectives can further suggest structural and societal changes to support a transition to sustainable mobility.

To conclude, this study has emphasised the great challenges involved in achieving sustainable travel, as motorization and dependence on the private car are so heavily embedded in everyday life in Malta. However, there are also many opportunities for interventions that can produce the required socio-structural shift towards more sustainable mobility. The potential sites of influence in practices become even more evident as we carry out further and more in-depth research in this area.

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# APPENDICES

**Appendix A: Phase 1 – Mobility practices**
Semi-structured interviews

**Appendix B: Phase 1 – Travel Survey**
Online Survey

**Appendix C: Phase 2 –Stakeholders' feedback on Future Visions**
Online Survey

**Appendix D: Phase 3 – Modelling $CO_2$ emissions of alternative futures**
Screenshots from ForFITS model

**Appendix E: Phase 4 – Policy Packing with Stakeholders**
Online Survey

**Appendix F: Phase 4 - Semi-structured Interviews with Experts**
Interview Guide

**Appendix G: Phase 4 – Policy identification for policy packaging**
List of identified policy options

## Appendix A: Phase 1 – Mobility practices
## Semi-structured interviews

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| Part 1: Introduction |
|---|
| Thank you for accepting my visit for an interview. As I explained when we took the appointment, I guarantee to preserve your anonymity. This interview is about how mobility practices are part of everyday lives. |
| **Part 2: Opening Questions** |
| **Section 1: Basic Information** |
| **Tell me about your self**<br>How old are you and how long have you been living here?<br>What are you doing at the moment in terms of work etc?<br>Who do you live with and what do the other members of the household do? |
| **Section 2: Background** |
| **Tell me about your background**<br>Describe your childhood through to present<br>Where did you grow up? Where did you go to school / college/university and how long have you been doing what you do?<br>Where do you work? And how long have you worked here? |
| **Part 3: Questions about everyday life and mobility** |
| **Section 3: About everyday life** |
| **Tell me about a typical day in your life**<br><br>Describe the things you do as part of your day-to-day life<br>What are the most important activities?<br>Do you perform the same activities everyday? What about your weekends?<br>Where do go to work? Where do you do your shopping?<br>What about other activities that you do?<br>Who participates with you in your activities (family/friends)?<br>Who are the key people in your life?<br>What activities do you perform with these people?<br>How often do you get to visit them? |
| **Section 5: About mobility** |

| | |
|---|---|
| **Tell me about your day-to-day travel**<br>Give me a general picture of how you travel during the week<br>How do you get to work / school etc?<br>Who do you travel with?<br>Do other household family members depend on you for their travel?<br>What mode of transport do you prefer?<br>Is there a difference between travel on weekends and weekdays?<br>How did you travel when you were a child?<br>Has everyday travel changed at different stages in your life? Why do you think this change has happened? | |
| **Part 4: In-depth questions on mobility practices** | |
| Practices discussed in this first part of the interview will be explored in more detail. Prompts will be used to gather information on materials, competencies and meanings. | |
| **Section 6: Specific Practice**<br>From our previous discussion, it seems that ________is one of the key mobility practices. Let's explore the practice in more detail. | |
| Materials | Can you describe in detail this specific practice?<br>Where does it start? What happens during the travel / journey?<br>How long does this practice take?<br>Do you perform this type of travel every day? And what time of the day does this form of travel take place?<br>Do you need to prepare to take this form of travel? If so in which way?<br>Who is part of this travel?<br>Think about what other activities take part during this practice?<br>What hinders/facilitates the way you travel? Why?<br>Can you give me a description of the other mobility options that you might use? |
| Competencies | Since when have you started using this practice?<br>How did you travel before you started using this practice?<br>Can you explain changes in your type of travel over the years? ***E.g. Use of the bus to go to school***<br>Why do you think this change happened? |
| | What would you change about the way you travel if you could? |
| | Are there things you can't change / don't know how to change? |
| Meanings | Why do you feel the need to travel? And Why do you choose to travel in the way is way? |
| | What do you value/enjoy about the way you travel? |
| | What annoys you about the way you travel? |
| | If you think back, did you feel differently about your travel / journeys at different points in your life? And what made you change the way you feel about travel? |
| | What do you think influences the way you travel? What in your opinion would make you change your choice of travel? |
| Bundles of Practices | From our discussion, it seems that your key activities are _______<br>You mention using _____ type of mobility to perform these activities.<br>Can you tell me why you chose this type of mobility?<br>Have you always chosen this option?<br>Do you know of other types of travel that you may use to perform this activity? |

| | |
|---|---|
| | Did you considered doing this differently? How would you change this practice? |
| **Part 5: Closing Questions** | |
| Are there any points which you want to elaborate further?<br>Is there anything you want to add to our discussion? | |

**A practice-based approach to studying mobility in Malta**

**Rosalie Camilleri**
**Institute for Sustainable Development and Climate Change,**
**University of Malta**

**Participant Information Sheet**

A study is being conducted in part fulfilment of the requirements of a Doctor of Philosophy Degree at the Institute of Climate Change and Sustainable Development at the University of Malta. The aim of this study is to analyse how a transition towards more sustainable transport in the Maltese Islands could contribute towards the achievement of the climate change mitigation targets.

Different methods of data collection will be employed in this study. One such method consists of interviews with a number of participants residing in Malta. The objective of this interview is to gather information on the current types of transport (or mobility) practices in the aim of this the results will be used to inform subsequent sections of the study on how the current transport practices can transformed into more sustainable forms.

The research is being carried out by Ms. Rosalie Camilleri under the supervision of Professor Maria Attard from the University of Malta co-supervised by Dr. Robin Hickman from University College London.

In this regard, I would like to ask you to participate in a semi-structured interview. The interview will not take longer than an hour. In this interview, you will be asked questions about the way you travel and your mode of transport. The research will not pose any risks or discomfort to the participants. Information from the research can potentially serve as a policy instrument in sustainable transport.

Participation in this research is voluntary and any refusal to participate will involve no penalty. You may also withdraw you participation at any time without any prejudice or negative consequences. The data collected will be treated in a confidential manner and all participants will remain anonymous. The results will only be used for the purpose of this research. However, data may be also used in published material by the Principal Investigator. In such case the anonymity of the research participants will be maintained.

The research participants may contact the Principal Investigator to request additional information about the study and/or information about how any personal data is being processed. The Principal Investigator may be contacted on e-mail rosalie.camilleri.04@um.edu.mt and mobile number 79265653.

Under the Data Protection Act, the research participants may request to access, rectify and where applicable erase the data concerning them. Furthermore, the participants may also contact the University of Malta Research Ethics Committee on research-ethics.committee@um.edu.mt to clarify any concerns about the conduct of the study.

**A practice-based approach to studying mobility in Malta**

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L-Università ta' Malta

## Participant Consent Form

1 I confirm that I have read and understood the participant information sheet and that the purpose and details of the study have been explained to me by the Principal Investigator (Rosalie Camilleri). ☐

2 I confirm that any difficulties which I have raised have been adequately clarified. ☐

3 I given consent to the Principal Investigator to make the required observations and I am aware that there are no risks or harm associated with this study. ☐

4 I understand that the results of this study which I am participating will be used for research purposes. The results of this study can be archived and used for further research projects by the Principal Investigator. The data may also be reported or published and I agree that I shall not be personally identified in any way either individually or collectively. ☐

5 I understand that I have the right to access, rectify, and where applicable erase data concerning me. ☐

6 I am under no obligation to participate in this study and am doing so voluntarily. ☐

7 I understand that I may withdraw from the study at any time, without giving any reason and without any prejudice and that any decision to do so will not have any negative consequences. ☐

8 I agree that the data will be processed anonymously and that only the researcher will have access to the raw data which will be kept confidentially. ☐

9 I have understood that I can ask the Principal Investigator for additional information on the study or for clarification on any issues. ☐

10 I agree that the interview will be audio-recorded ☐

| | |
|---|---|
| Name of Participant: | __________________________________ |
| Signature / Date: | __________________________________ |
| | |
| Principal Investigator: | Ms. Rosalie Camilleri |

| | |
|---|---|
| Signature / Date: | ________________________________________ |
| Supervisor: | Prof. Maria Attard |
| Signature / Date: | ________________________________________ |

## Appendix B: Phase 1 – Travel Survey
## Online Survey

# Travel Survey

Tell us about your mobility

## Page 1

**Welcome / Merħba**

**Choose a language / Agħżel lingwa**
○ English ○ Malti

## Introduction

This questionnaire is part of a wider study aimed at examining how transport on the islands can be more sustainable. The project is being carried out at the Institute for Climate Change and Sustainable Development at the University of Malta under the supervision of Prof. Maria Attard. Any questions on the project can be sent to the researcher on the following e-mail address: rosalie.camilleri.04@um.edu.mt.

Your response is very important in helping us learn what factors affect the way we travel and in which areas interventions are needed to facilitate sustainable transport.

The survey does not take long to complete (10 minutes). All data will remain anonymous as it will be used solely for statistical purposes. The results will only be presented in aggregated form and no answers will be forwarded to third party.

Participation in this study is on a voluntary basis and should you decided to participate, you may withdraw your participation at any time. Completion of the survey will be taken as consent of participation.

Should you be interested to further participate in a face-to-face interview regarding this topic, kindly contact me on the following address: rosalie.camilleri.04@um.edu.mt.

Thank you for your contribution.

Rosalie Camilleri

# Page 3

## Background Info

*This section collects information on the demographics of the participants. Questions provide background information for statistical analysis and data interpretation.*

**1. Please indicate your AGE**

**2. What is your gender?**
○ Male ○ Female ○ Other ○ I prefer not to anwser

**3. In which locality do you currently live?**

**4. Please state your nationality**
○ Maltese

⊙

**5. What is your highest level of education?**
☐ Compulsory level
☐ Secondary
☐ Post-secondary
☐ Diploma
☐ Vocational Training
☐ Undergraduate
☐ Postgraduate
☐ Doctorate

**6. Which of the following best describes your employment?**
○ Senior Management
○ Management
○ Junior Management / Executive
○ Professional Occupation (E.g. Lawyer, teacher, engineer)
○ Vocational Occupation
○ Technicians and Associated Professionals
○ Administrative Roles (e.g. Clerks)
○ Skilled Worker / Tradeperson (e.g.
○ Stay-at-home worker/ Caregiver/ Parent
○ Student
○ Unemployed
○ Self-employed / Partner
○ Researcher
○ Sales and Services
○ Retired

**7. How many persons including you live in your household?**

**8. Are you responsible for the care of dependent others?**
○ No
○ Yes, I am the prime carer of dependent other(s)
○ Yes, but someone else is the prime carer of dependent other(s)
○ Yes, I equally share the care of dependent other(s)

## Page 4

## Record Your Trips

- Think about **ALL** the trips you have carried on one **WEEKDAY** (e.g. yesterday or a day from last week) and one day on a **WEEKEND**.
- The instructions below will guide you to fill the information.

## Instructions

- The day is taken to start at 4am until you go to sleep.
- Fill in ONE Line for each TRIP. For Example Home to work is Trip 1; Work to Gym is Trip 2; Gym to Home is Trip 3.
- The same applies for weekend trips. For Example Home to Shop is Trip 1; Shop to Home is Trip 2
- If you take a round-trip without stopping record the furthest part of the trip as the end location.
- If you use multiple modes of transport for a single trip, do record all transport modes.
- If your work involves making frequent trips, do not record these in the travel diary.
- When you have finished entering the information for one trip press ***+Add Trip*** to start inputting details for next trip.

## Weekday Trips - Record all trips for one day

*For each trip use a separate entry*

### Trip 1

**1. WHERE did your trip START?**

*Choose one locality from the list*

**2. WHERE did your trip END?**

*Choose one locality from the list*

**3. At what TIME did you LEAVE?**

**4. At what TIME did you ARRIVE?**

**5. Which activity did you do at your Destination?**

*Select from list*

**6. If you have chosen other activity please specify**

**7. Which MODE did you use to travel?**

☐ Car driver

☐ Car Passenger

☐ Bus

☐ Minibus / Coach

☐ Motorcycle

☐ Ferry

☐ Walk

☐ Bicycle

☐ Taxi

*One trip can include more than one mode of transport*

**8. How many other persons were travelling with you?**

## Page 5

## Weekend Trips - Record all trips for one day

*For each trip use a separate entry*

### Trip 1

**1. WHERE did your trip START?**

*Choose one locality from the list*

**2. WHERE did your trip END?**

*Choose one locality from the list*

**3. Please tell us at what TIME did you LEAVE?**

**4. Please tell us at what TIME did you ARRIVE?**

**5. Which activity did you do at your Destination?**

*Select from list or type in your entry*

**6. If you have chosen other please specify**

**7. Which MODE did you use to travel?**

☐ Car driver

☐ Car Passenger

☐ Bus

☐ Minibus / Coach

☐ Motorcycle

☐ Ferry

☐ Walk

☐ Bicycle

☐ Taxi

*One trip can include more than one mode of transport*

**8. How many other persons were travelling with you?**

## Page 6

## Introduzzjoni

Dan il-kwestjonarju huwa parti minn studju usa' li għandu l-għan li jistħarreġ kif it-trasport fil-Gżejjer Maltin jista' jkun aktar sostenibbli.

Dan il-proġett qed isir fl-Istitut tat-Tibdil fil-Klima u l-Iżvilupp Sostenibbli, fl-Universita' ta' Malta taħt is-superviżjoni ta' Prof. Maria Attard. Mistoqsijiet dwar dan il-proġett jistgħu jintbagħtu lir-riċerkatriċi fuq l-indirizz elettroniku tagħha rosalie.camilleri.04@um.edu.mt.

Is-survey ma joħodlokx ħafna ħin biex tlestih (madwar 10 minuti). Se jittieħdu l-prekawzjonijiet meħtieġa biex tiġi ssalvagwardjata l-anonimità tad-dejta miġbura. Id-dejta se tintuża biss għal skopijiet ta' statistika. Ir-riżultati se jkunu ppreżentati biss f'ammonti magħduda flimkien u l-ebda risposta mhu se tkun mgħoddija lil terza persuni.

Il-parteċipazzjoni f'dan l-istudju hija fuq bażi volontarja u jekk tiddeċiedi li tieħu sehem tista' tieqaf meta u fi xħin trid.

Jekk tkun tixtieq li niltaqgħu biex tipparteċipa f'intervista fuq dan is-suġġett, tiddejjaqx tiktibli fuq rosalie.camilleri.04@um.edu.mt.

Grazzi tal-kontribuzzjoni tiegħek.

Rosalie Camilleri

## Page 7

## Informazzjoni demografika

**1. Jekk jogħġbok indika kemm għandek żmien**

**2. X'inhu l-ġeneru (ġender) tiegħek?**
○ Raġel ○ Mara ○ Oħra ○ Nipreferi ma nweġibx

**3. F'liema lokalità tgħix bħalissa?**

**4. Indika n-nazzjonalità tiegħek**
○ Maltija

⊙

**5. X'inhu l-ogħla livell tiegħek ta' edukazzjoni?**
☐ Livell obbligatorju
☐ Sekondarja
☐ Postsekondarja
☐ Diploma
☐ Taħriġ Vokazzjonali
☐ Gradwat
☐ Postgradwat
☐ Dottorat

**6. Liema minn dawn jiddeskrivu l-aħjar ix-xogħol tiegħek?**
○ Senior Management
○ Management
○ Junior Management / Executive
○ Xogħol ta' professjoni
○ Xogħol tekniku
○ Tekniċi u Professjonisti Assoċjati
○ Rwoli Amministrattivi (eż. Skrivan)
○ Ħaddiem tas-sengħa / Tradeperson
○ Tieħu ħsieb id-dar/ Caregiver / Ġenitur full-time
○ Student
○ Unemployed
○ Self-employed
○ Riċerkatur
○ Taħdem fil-qasam ta' bejgħ u Servizzi
○ Irtirat

**7. Kemm jgħixu nies ġewwa darek? (Għodd ukoll lilek innifsek)**

**8. Inti responsabbli għall-kura ta' dipendenti oħrajn?**
○ Le
○ Iva, Jiena l-carer ewlieni ta' dipendenti oħra
○ Iva, imma hemm xi ħadd ieħor bħala l-carer ewlieni
○ Iva, imma naqsam ir-responsabbiltà tal-kura ta' dipendenti oħra

*per eżempju anzjani, tfal*

**9. Għandek tfal?**

○ Iva

○ Le

○ Nipreferi ma nweġibx

**10. Għandek xi wieħed minn dawn il-mezzi tat-trasport?**

☐ Karozza

☐ Rota

☐ Mutur

☐ Van

☐ Rota tal-elettriku

☐ Karozza tal-elettriku

☐ Oħrajn

**11. Liema mezz tat-trasport tippreferi l-aktar?**

**12. Liema mezzi oħra tat-trasport tuża?**

# Page 8

## Irreġistra l-vjaġġi tiegħek

- Aħseb f'ġurnata **MATUL IL-ĠIMGĦA** (per eżempju lbieraħ jew xi ġurnata minn ġimgħa ilu) u f'ġurnata fi **TMIEM IL-ĠIMGĦA**. Tista' tiddeskrivi l-vjaġġi **KOLLHA** li għamilt f'dawn il-ġranet?
- L-istruzzjonijiet t'hawn taħt se jiggwidawk biex timla l-informazzjoni.

## Kif timla s-sezzjoni li jmiss

- Ikkunsidra li l-ġurnata tibda fl-4am u tispiċċa fil-mument li tidħol torqod.
- Imla linja WAĦDA għal kull VJAĠĠ. Per eżempju Vjaġġ 1: mid-dar għal post tax-xogħol; Vjaġġ 2: mill-post tax-xogħol għal Ġinnasju; Vjaġġ 3: Ġinnasju għad-dar.
- Iinkludi wkoll il-waqfiet għall-kafè jew għall-petrol, jew jekk niżżiltx u/jew ġbart lil xi ħadd.
- Jekk se tagħmel vjaġġ għal xi post u lura mingħajr ma tieqaf, irrekordja l-aktar punt 'il bogħod tal-vjaġġ bħala t-tmiem tal-lokazzjoni.
- Jekk se tuża aktar minn mod wieħed ta' trasport għal vjaġġ wieħed, irrekordja kull mod ta' trasport.
- Jekk xogħlok jinkludi li tagħmel vjaġġi frekwenti, tirrekordjahomx.
- Meta tiffinalizza l-informazzjoni għal xi vjaġġ, agħfas ***+ Add Vjaġġ*** biex tibda ddaħħal id-dettalji għall-vjaġġ li jkun imiss.

## Niżżel il-vjaġġi kollha ta' gurnata matul il-ġimgħa (Weekday)

*Għal kull vjaġġ uża entrata separata*

### Vjaġġ 1

**1. MINN fejn BEDA l-vjaġġ tiegħek?**

*Agħżel lokalità waħda mil-lista*

**2. FEJN SPIĊĊA l-vjaġġ tiegħek?**

*Agħżel lokalità waħda mil-lista*

**3. Fi XĦIN TLAQT?**

**4. Fi XĦIN WASALT?**

**5. X'attività għamilt fid-destinazzjoni tiegħek?**

*Agħżel mil-lista*

**6. Jekk għażilt "oħrajn" jekk jogħġbok speċifika**

**7. Liema MOD użajt biex tivvjaġġa?**

☐ Xufier ta' karozza

☐ Passiġġier ta' karozza

☐ Il-karozza tal-linja

☐ Il-minibus/Il-kowċ

☐ Il-Mutur

☐ Il-lanċa

☐ Il-mixi

☐ Ir-rota

☐ It-taxi

*Vjaġġ wieħed jista' jinkludi iktar minn mod wieħed ta' trasport*

**8. Kemm kien hemm nies jivvjaġġaw miegħek?**

## Page 9

## Niżżel il-vjaġġi kollha ta' gurnata fi tmiem il-ġimgħa (Weekend)

*Għal kull vjaġġ uża entrata separata*

### Vjaġġ 1

**1. MINN fejn BEDA l-vjaġġ tiegħek?**

*Agħżel lokalità waħda mil-lista*

**2. FEJN SPIĊĊA l-vjaġġ tiegħek?**

*Agħżel lokalità waħda mil-lista*

**3. Fi XĦIN TLAQT?**

**4. Fi XĦIN WASALT?**

**5. X'attività għamilt fid-destinazzjoni tiegħek?**

*Agħżel mil-lista*

**6. Jekk għażilt "oħrajn" jekk jogħġbok speċifika**

**7. Liema MOD użajt biex tivvjaġġa?**

☐ Xufier ta' karozza

☐ Passiġġier ta' karozza

☐ Il-karozza tal-linja

☐ Il-minibus/Il-kowċ

☐ Il-Mutur

☐ Il-lanċa

☐ Il-mixi

☐ Ir-rota

☐ It-taxi

*Vjaġġ wieħed jista' jinkludi iktar minn mod wieħed ta' trasport*

**8. Kemm kien hemm nies jivvjaġġaw miegħek?**

# Appendix C: Phase 2 –Stakeholders' feedback on Future Visions Online Survey



## Scenario Development

Sustainable Transport Scenarios for 2050.

This scenario development exercise is part of a multi-phase process research project aimed at investigating how transport can better contribute to lowering carbon emissions and achieve the climate change mitigation targets.

The first and second phases of the project have already been completed. The first phase of the project involved collecting data on the current mobility practices in Malta. The second phase consisted of a stakeholder workshop which aim was to generate desirable sustainable mobility visions for the year 2050.

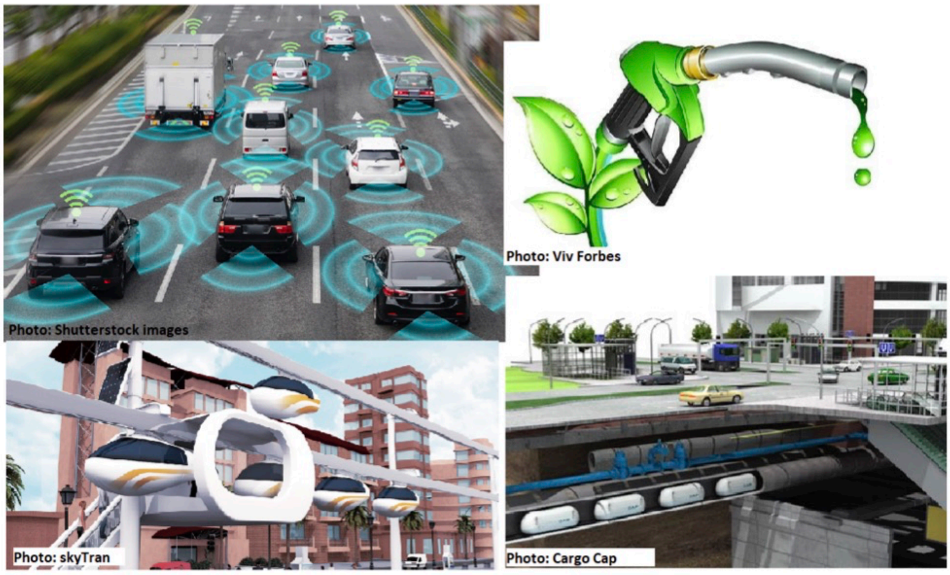
Scenario development is what follows after first and second phases of the project. This phase involves using the visioning concepts generated during the visioning workshop to develop alternative scenarios for the year 2050. The input of the visioning workshop participants is an important aspect of the scenario development process.

Following the visioning workshop three initial scenario have been sketched by the researcher. The next sections present a description of each of these scenarios. Your role is to read the descriptions and give your comments for each of the scenarios.

* Required

| | |
|---|---|
| Scenario 1: Tech Future | This scenario describes a future where people still feel the need for more travel. Individuals have very busy lifestyles and are moving fast from one point to another. However, technology has evolved in such a way as to allow this fast movement while at the same time reduce the emissions generated from the road transport sector.<br><br>In this scenario, personal transport consists mainly of connected and autonomous vehicles (CAVs). The CAVs are electrical and are powered by electricity coming from renewable resources. When they are parked, the vehicles are charged and also undergo any repairs and maintenance which is necessary. Through various educational programs set in place, individuals are capable of operating and using the CAVs very easily. Sharing of trips in CAVs serves also as a means of social integration where individuals are no longer isolated within their personal car but can socialise during their day-to-day travel.<br><br>A small number of individuals still make use of the car for personal travel. However, these run on a new fuel which produces only small amounts of $CO_2$ relative to the conventional fuels.<br><br>Transport capsules characterise the mass transport system. These capsules, are suspended above ground and are powered by solar panels on the roof of the capsules. A network of capsule lines allows very fast movement of people from one place to another. The network is designed is such a way as to allow for easy changes between other modes of transport. Bike sharing facilities are available close to the stops of the capsule lines and bicycles can be transported inside the capsules. CAVs are connected to the capsules to allow for easy transfer from one mode to another. Another capsule system runs in parallel underground and is used for the transport of goods. |

Scenario 1




1. Do you agree with this scenario? *

   *Mark only one oval.*

   ◯ Agree

   ◯ Disagree

2. If you agree with this scenario, is there anything you would add? If yes please include your comments below.

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

   ______________________________________________

3. If you disagree with this scenario what would you change?

| | |
|---|---|
| Scenario 2: Moving Actively | In this scenario, technology has enabled individuals to adopt a lifestyle where they travel less or make use of active forms of mobility. Workplaces have been equipped with video-conferencing facilities. Employees have less stringent times during which they need to be at the workplace. The automation of many processes and the development of technology facilitates work from home. This has greatly reduced the need to travel to and from the workplace. Where travelling is necessarily, this is done through communal transport which companies provide for free to their employees.<br><br>Tertiary education is based on e-learning and in this way students need to spend less time on campus. They need to commute less to University and this reduces the number of trips. IT technology has improved and this makes e-learning an enjoyable experience for students.<br><br>Educational programs aimed at improving IT skills have facilitated the use of mobile applications for public transport. With these applications individuals can plan the best route and have information in real time on the location of the bus, so that they can plan their journey more effectively without losing time.<br><br>Electric scooters and mobile walkways help individuals to travel over short distances. People have learnt that the car is no longer a sign of status.<br><br>Travelling for shopping is reduced by an autonomous underground system which delivers goods. Other goods which are not delivered through this system are transported and delivered by drones.<br><br>For longer travel distances, the individuals can opt to take cable cars or travel pods. These are powered by electricity which comes from renewable resources. |

Scenario 2


4. Do you agree with this scenario? *

*Mark only one oval.*

- Agree
- Disagree

5. If you agree, is there anything you would add? If yes please insert your comments below

6. If you disagree with this scenario, what would you change?

| | |
|---|---|
| Scenario 3: Green Planning | The urban environment has been designed to provide a green environment where active travel is prioritised over other forms of transport. Urban planning is now such that there is a network of green spaces. Individuals can now walk between these interconnected green spaces using footpaths which are wide, safe and free from obstructions.<br><br>The urban community is well aware about the health benefits of active travel over other modes of transport. Tax benefits are in place for those who chose to travel using active modes of travel including walking and the electrical bicycle. Signs along walking paths which show actual distances between localities provide pedestrians with the knowledge about the actual distances and the best route they need to take.<br><br>Buses are available at the periphery of this new urban plan and they run on separate lanes than those used for walking or cycling. Low-emission zones and parking taxes mean that the use of cars is greatly discouraged. They are also segregated at the periphery of the urban environment. However, other forms of travel are preferred. |

Scenario 3


7. Do you agree with this scenario? *

*Mark only one oval.*

- ⬭ Agree
- ⬭ Disagree

8. If you agree, is there anything you would add? If yes please insert your comments below

9. If you disagree with this scenario, what would you change?

10. Please provide your name (this is to ensure all participants have given their feedback)

## Appendix D: Phase 3 – Modelling $CO_2$ emissions of alternative futures
## Screenshots from ForFITS model for Scenario 1

### Economic & demographic data

#### Base year

**Population**
[people]

| | 2018 | |
|---|---|---|
| SERVICE | I | II |
| PASSENGER | Malta | Malta |
| FREIGHT | Malta | Malta |

| | AREA | |
|---|---|---|
| SERVICE | I | II |
| PASSENGER | 493559 | 493559 |
| FREIGHT | 493559 | 493559 |
| Check | OK | |

**GDP**
[constant base year USD, PPP]

| | AREA | |
|---|---|---|
| SERVICE | I | II |
| PASSENGER | Malta | Malta |
| FREIGHT | Malta | Malta |

| | AREA | |
|---|---|---|
| SERVICE | I | II |
| PASSENGER | 2.111E+10 | 2.111E+10 |
| FREIGHT | 2.111E+10 | 2.111E+10 |
| Check | OK | |

**GDP deflator**
**(2000 to the base year)**

| | 2018 |
|---|---|
| GDP deflator (2000 to the base year) | 2.118479052 |

#### Over time

**Population growth**
[dimensionless index] and [people]

**Index**

| | | | TIME | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SCENARIO | SERVICE | AREA | 2018 | 2015 | 2020 | 2025 | 2039 | 2044 | 2050 |
| Malta | PASSENGER | I | 1 | 0.878434 | 1.0271335 | 1.1294009 | 1.2786131 | 1.3154152 | 1.3541907 |
| Malta | | II | 1 | 0.878434 | 1.0271335 | 1.1294009 | 1.2786131 | 1.3154152 | 1.3541907 |
| Malta | FREIGHT | I | 1 | 0.878434 | 1.0271335 | 1.1294009 | 1.2786131 | 1.3154152 | 1.3541907 |
| Malta | | II | 1 | 0.878434 | 1.0271335 | 1.1294009 | 1.2786131 | 1.3154152 | 1.3541907 |

**GDP growth**
[dimensionless index] and [contant 2000 USD, PPP]

**Index**

| | | | TIME | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SCENARIO | SERVICE | AREA | 2018 | 2015 | 2020 | 2025 | 2039 | 2044 | 2050 |
| Malta | PASSENGER | I | 1 | 0.8396193 | 1.122 | 1.332 | 1.83 | 1.93 | 2.042 |
| Malta | | II | 1 | 0.8396193 | 1.122 | 1.332 | 1.83 | 1.93 | 2.042 |
| Malta | FREIGHT | I | 1 | 0.8396193 | 1.122 | 1.332 | 1.83 | 1.93 | 2.042 |
| Malta | | II | 1 | 0.8396193 | 1.122 | 1.332 | 1.83 | 1.93 | 2.042 |

# Initial transport system
# (vehicles, travel and loads)

## Vehicle stock

### Vehicles

2018

**Number of active vehicles**
**(vehicle stock, base year)**
[vehicles]

**Note: for pipelines, each cubic metre transported is considered as a "vehicle". As a result, the input required for pipelines corresponds to the annual volume transported, express**

| | AREA | |
|---|---|---|
| SERVICE | I | II |
| PASSENGER | Malta | Malta |
| FREIGHT | Malta | Malta |

| | | AREA | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | I | | | | | | |
| | | VEHICLE CLASS | | | | | | |
| SERVICE | MODE | A | B | C | D | E | F | BY MODE |
| PASSENGER | NMT | 500 | 3200 | | | 0 | 0 | |
| | TWO WHEELERS | 27329 | 0 | 0 | 0 | 0 | 0 | 27329 |
| | THREE WHEELERS | 1207 | 0 | 0 | 0 | 0 | 0 | 1207 |
| | LDVS | 300141 | 0 | 0 | 0 | 0 | 0 | 300141 |
| | VESSELS | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LARGE ROAD | 2111 | 0 | 0 | 0 | 0 | 0 | 2111 |
| | RAIL | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AIR | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | PIPELINES | | | | | | | |
| FREIGHT | NMT | | | | | | | |
| | TWO WHEELERS | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | THREE WHEELERS | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LDVS | 37056 | 0 | 0 | 0 | 0 | 0 | 37056 |
| | VESSELS | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LARGE ROAD | 15365 | 0 | 0 | 0 | 0 | 0 | 15365 |
| | RAIL | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | AIR | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | PIPELINES | 0 | 0 | 0 | 0 | 0 | 0 | |

**Powertrain group shares in each vehicle class**
**(vehicle stock, base year)**
[% of vehicles in the same vehicle class]

| | **AREA** | |
|---|---|---|
| **SERVICE** | I | II |
| PASSENGER | Malta | Malta |

| | | | **AREA** | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | I | | | | | | | |
| | | | **POWERTRAIN GROUP** | | | | | | | |
| **SERVICE** | **MODE** | **VEHICLE CLASS** | GASOLINE I | GASOLINE I | METHANE F | LPG PI ICE | DIESEL CI I | DIESEL CI I | ELECTRIC | Check |
| PASSENGER | TWO WHEELERS | A | 0.9964236 | 0 | 0 | 0 | 0.0007315 | 0 | 0.0028448 | OK |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | THREE WHEELERS | A | 0.9639262 | 0 | 0 | 0 | 0 | 0 | 0.0360738 | OK |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | LDVS | A | 0.6777481 | 0.0019245 | 0 | 0.0041474 | 0 | 0.3155008 | 0.0006792 | OK |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | LARGE ROAD | A | 0.0048333 | 0.0024166 | 0 | 0 | 0.9927501 | 0 | 0 | OK |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | RAIL | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | OK |

# Transport system over time

## Passenger

**Area characterization**
[switch]

2018

**Selection switches**

| | AREA | |
|---|---|---|
| SERVICE | I | II |
| PASSENGER | URBAN | URBAN |

**Note**
Inputs characterizing each area affect the way the way other aprameters are affected by changes in key modelling inputs having an impact on demand generation and modal choice

**Passenger transport system index**
[index]

**Variation index**

| | | TIME | | | | | | |
|---|---|---|---|---|---|---|---|---|
| SCENARIO | AREA | 2018 | 2023 | 2028 | 2034 | 2039 | 2044 | 2050 |
| Scenario 1 | I | 1 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 |
| Scenario 1 | II | 1 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 |

**Explanatory table for index values**

| | |
|---|---|
| 0 | Focus on personal vehicles, low density of population, significant presence of urban sprawl, horizontal urban development |
| 1 | Very high density of population, vers strong focus on public transport, geographcal and other constraints leading to the vertical development of the urban area |

Examples:
0 to 0.3 Rural areas, low-density cities (e.g. urban areas with significant sprawl, frequent in North American cities)
0.6 to 0.8 Densely populated areas (e.g. dense cities in Asia)
0.45 to 0.65 Average European urban values

**Environmental culture index**
[index]

**Variation index**

| | | | TIME | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **SCENARIO** | **SERVICE** | **AREA** | 2018 | 2023 | 2028 | 2034 | 2039 | 2044 | 2050 |
| CONSTANT | PASSENGER | I | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CONSTANT | | II | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

**Explanatory table for inputs**

| | |
|---|---|
| 0 | Low "environmental culture" |
| 1 | High "environmental culture" |

0.5 initial value by default (the user can cgange it)

# TIME-DEPENDENT INPUTS

## Fuel consumption characteristics

### All modes but air, NMT and pipelines

**Index of performance**
**(excluding air, NMT and pipelines)** 2018

**Index**
[dimensionless]

| | | | TIME | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **SCENARIO** | **SERVICE** | **MODE** | 2018 | 2023 | 2028 | 2034 | 2039 | 2044 | 2050 |
| EU Regulations | | TWO WHEELERS | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | THREE WHEELERS | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | LDVS | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | VESSELS | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | LARGE ROAD | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | RAIL | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | FREIGHT | TWO WHEELERS | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | THREE WHEELERS | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | LDVS | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | VESSELS | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | LARGE ROAD | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |
| EU Regulations | | RAIL | 1 | 1 | 0.85 | 0.625 | 0.625 | 0.625 | 0.625 |

# Powertrain technology & ICE fuel: shares

**Powertrain shares**
**(except air, NMT and pipelines, for which there is no powertrain choice)**

**Powertrain technology**

| | SELECTION |
|---|---|
| BASE YEAR | 2018 |
| FOLLOWING TIMES [self-reordering] | Scenario 1 |
| | User 11 |
| | User 1 |
| | User 1 |
| | User 1 |
| | User 11 |

| TIME | |
|---|---|
| 2018 | 2050 |

| CASES | | | | | | | |
|---|---|---|---|---|---|---|---|
| DEFAULT FF | LAST YEAR | TECH SCEN | TECH SCEN | TECH SCEN | Scenario 1 | User 6 | User 7 |
| 2018 | 2050 | 2040 | 2040 | 2040 | 2050 | 2050 | 0 |

| | | SCENARIO | CALCULATED ON THE BASIS OF "User inputs (BASE Y)" | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | TIME | 2018 | | | | | | | |
| | | | POWERTRAIN TECHNOLOGY | | | | | | | |
| SERVICE | MODE | VEHICLE CLASS | ICE | ICE-HYDRAULIC HYBRID | ICE-ELECTRIC HYBRID | ICE-ELECTRIC PLUG-IN HYBRID | FC | FC-ELECTRIC HYBRID | FC-ELECTRIC PLUG-IN HYBRID | ELECTRIC |
| PASSENGER | TWO WHEELERS | A | 0.97228989 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02771011 |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | THREE WHEELERS | A | 0.58333333 | 0 | 0 | 0 | 0 | 0 | 0 | 0.41666667 |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LDVS | A | 0.94897069 | 0 | 0.02962164 | 0 | 0 | 0 | 0 | 0.02140767 |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | VESSELS | A | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | B | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | C | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | D | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | E | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | F | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | LARGE ROAD | A | 0.91836735 | 0 | 0 | 0 | 0 | 0 | 0 | 0.08163265 |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | RAIL | A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# Appendix E: Phase 4 – Policy Packing with Stakeholders Online Survey



# Sustainable Mobility for 2050: Backcasting

The aim of this research project is to develop a policy framework which can enable the reduction of CO2 emissions from the transport sector in Malta. The project consists in the development of future visions for transport in 2050, followed by design of policies to achieve the visions.

A set of visions for the transport sector in Malta in 2050 have already been developed during a workshop held last February. The next phase -the backcasting phase- involves working backwards from these visions and designing policy pathways through which such visions can be achieved.

Your are invited to participate in the backcasting phase of this research. This survey will guide you in providing your input.

* Required

The first step in this backcasting exercises is to develop policy packages which can enable the achievement of the future visions. A policy package can be defined as a combination of policy measures, created in order to improve the effectiveness of the individual policy measures, while minimising possible unintended effects, and/or facilitating interventions' feasibility.

The next sections provide a description of the the alternative transport future scenarios for 2050. A list of policy measures which may be suitable to achieve this vision is also provided. Your task is design policy packages to reach these futures.

1. Please enter your name *

| | |
|---|---|
| Scenario 1: High Tech Mobility | This scenario describes a future where the demand for travel is still strong. Individuals have very<br>busy lifestyles and are moving fast from one point to another. However, technology has<br>evolved in such a way as to allow for an easy transition from private car to mass transit<br>travel.<br><br>A new form of transport system characterises the mass transport system.  A high density network of transport capsule lines allows very fast movement of people from one place to another. The system, which is powered by clean energy, is designed is such a way as to allow for easy interchanges between other modes of transport. Bicycle sharing facilities are available close to the stops of the capsule lines and bicycles can be transported inside the capsules. A parallel underground systems enable the transport of goods.<br><br>In addition, a fully electrical bus fleet with segregated lanes provides quality transport for the<br>bulk of mobility needs.<br><br>In this scenario, individuals make use of connected and autonomous vehicles (CAVS) and conventional cars for personal mobility.  CAVS allow easy sharing of trips which also serves as a means of social integration where individuals are no longer isolated within their personal car but can socialise during their day-to-day travel.<br>Private cars, on the other hand, run on new fuels with low carbon emissions. |

When designing the packages keep in mind that an effective policy package includes measures which are similar, work well together and create positive synergies. E.g Policy package 1: Tax on fossil fuels + investment in new mass transport + reduced bus fares.  You may also refer to the preliminary assessment of the current transport system (attached to the covering e-mail)  to identify gaps which need to be addressed through policy in order to achieve the target transport visions. The number of policy packages designed is up to you.  You can choose measures and feature them in multiple policy packages (not necessarily once). Additional policies to the ones listed may also be added through the next section. Comments on the rationale used to design policy packages can be also included with next section.

2. For each each policy package number, tick the measures which you want to include in that package.

*Check all that apply.*

| | Policy Package 1 | Policy Package 2 | Policy Package 3 | Policy Package 4 | Policy Package 5 |
|---|---|---|---|---|---|
| **Tax increase on fossil fuels** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **National road pricing** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Parking Pricing** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **R&D incentives to encourage the development of new technologies** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Measure to improve vehicle emission standards** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Introduction of new fuels** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Regulations targeted at improving efficiency of conventional vehicles** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **License fee based on fuel efficiency** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Introduction of smart vehicles** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Integrated multi-modal level information** | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| information | | | | | |
| Individualised travel planning | ☐ | ☐ | ☐ | ☐ | ☐ |
| Increased network of bike sharing | ☐ | ☐ | ☐ | ☐ | ☐ |
| Integrated ticket system for bus, mass transit and shared bicycle facilities | ☐ | ☐ | ☐ | ☐ | ☐ |
| Investment in new mass transit system | ☐ | ☐ | ☐ | ☐ | ☐ |
| Public transport fare structures such as flat rates, zonal fares and monthly passes | ☐ | ☐ | ☐ | ☐ | ☐ |
| Location of bus stops close to employment centres | ☐ | ☐ | ☐ | ☐ | ☐ |
| New modified bus service | ☐ | ☐ | ☐ | ☐ | ☐ |
| Provision of real-time information about public transport travel alongside information related to travel with the car | ☐ | ☐ | ☐ | ☐ | ☐ |

3. Additional Policy Measures / Comments for Policy Package 1

4. Additional Policy Measures / Comments for Policy Package 2

5. Additional Policy Measures / Comments for Policy Package 3

6. Additional Policy Measures / Comments for Policy Package 4

7. Additional Policy Measures / Comments for Policy Package 5

| | |
|---|---|
| Scenario 2: Local Mobility | In this scenario, the use of technology is focused on enabling lifestyles with high mobility at the local scale through forms of active travel. This future illustrates a world where the need to travel over long distances to perform the daily activities has been reduced. Individuals are still mobile, however now they are traveling more locally over shorter distances.<br><br>An efficient IT infrastructure now permits businesses to shift part of their operations to remote working. This has greatly reduced the need to travel to and from the workplace. Where travelling to work is necessarily, this is done through on-demand shared transport which companies provide for free to their employees.<br><br>In this future, universities and high-level education institutions have integrated e-learning as part of their methods for education. Students can make use of technology to follow course materials and commute less to University. Improvements in IT enables easy access to education and makes e-learning an enjoyable experience for students. Local centres compliment the e-learning facilities. These centres provide a space where students can utilise facilities and interact with other students.<br><br>Electric scooters and travel escalators help individuals to travel over short distances. People have learnt that the car is no longer a sign of status. Shopping for goods over the internet is largely promoted and helps reduce the number of trips to large supermarkets. Goods are delivered to homes via clean transport modes.<br><br>Travel for other activities such as childcare and social activities can take place through electric vehicles, where a managed fleet of autonomous vehicles are available for select trip purposes. These are not owned privately but managed centrally or through Mobility As A Service (MAAS) services which are regulated. Private cars are electric and are used for long distance travel. These cars are not allowed in low-emission zones and town centres.<br><br>Travel over longer distances is facilitated by a dense network of public transport. Educational programmes aimed at improving IT skills have facilitated the use of mobile applications for public transport. With these applications individuals can plan the best route and have information in real-time on the location of the bus, so that they can plan their journey more effectively. |

When designing the packages keep in mind that an effective policy package includes measures which are similar, work well together and create positive synergies. E.g Policy package 1: Tax on fossil fuels + investment in new mass transport + reduced bus fares. You may also refer to the preliminary assessment of the current transport system (attached to the covering e-mail) to identify gaps which need to be addressed through policy in order to achieve the target transport visions. The number of policy packages designed is up to you. You can choose measures and feature them in multiple policy packages (not necessarily once). Additional policies to the ones listed may also be added through the next section.

# Appendix F: Phase 4 - Semi-structured Interviews with Experts Interview Guide

| **Scenario 1: Narrative** |
|---|
| This scenario describes a future where the demand for travel is still strong. Individuals have very busy lifestyles and are moving fast from one point to another. However, technology has evolved in such a way as to allow for an easy transition from private car to mass transit travel.<br><br>A new form of transport system characterises the mass transport system. A high density network of transport capsule lines allows very fast movement of people from one place to another. The system, which is powered by clean energy, is designed is such a way as to allow for easy interchanges between other modes of transport. Bicycle sharing facilities are available close to the stops of the capsule lines and bicycles can be transported inside the capsules. A parallel underground systems enable the transport of goods.<br><br>In addition, a fully electrical bus fleet with segregated lanes provides quality transport for the bulk of mobility needs.<br><br>In this scenario, individuals make use of connected and autonomous vehicles (CAVS) and conventional cars for personal mobility. CAVS allow easy sharing of trips which also serves as a means of social integration where individuals are no longer isolated within their personal car but can socialise during their day-to-day travel. Private cars, on the other hand, run on new fuels with low carbon emissions. |
| Questions:<br><br>What interventions can help achieve this scenario?<br>How can these interventions be combined with other policies that help to increase their effectiveness, acceptability and feasibility?<br>What time frames should be used for their implementation? (Short 2021-2030; Medium 2030-2040; Long 2040-2050).<br>Who are the key actors for implementation? (Local governance, national government?) |
| **Scenario 2** |
| In this scenario, the use of technology is focused on enabling lifestyles with high mobility at the local scale through forms of active travel. This future illustrates a world where the need to travel over long distances to perform the daily activities has been reduced. Individuals are still mobile, however now they are traveling more locally over shorter distances.<br><br>An efficient IT infrastructure now permits businesses to shift part of their operations to remote working. This has greatly reduced the need to travel to and from the workplace. Where travelling to work is necessarily, this is done through on-demand shared transport which companies provide for free to their employees.<br><br>In this future, universities and high-level education institutions have integrated e-learning as part of their methods for education. Students can make use of technology to follow course materials and commute less to University. Improvements in IT enables easy access to education and makes e-learning an enjoyable experience for students. Local centres compliment the e-learning facilities. These centres provide a space where students can utilise facilities and interact with other students. |

| |
|---|
| Electric scooters and travel escalators help individuals to travel over short distances. People have learnt that the car is no longer a sign of status. Shopping for goods over the internet is largely promoted and helps reduce the number of trips to large supermarkets. Goods are delivered to homes via clean transport modes.<br><br>Travel for other activities such as childcare and social activities can take place through electric vehicles, where a managed fleet of autonomous vehicles are available for select trip purposes. These are not owned privately but managed centrally or through Mobility As A Service (MAAS) services which are regulated. Private cars are electric and are used for long distance travel. These cars are not allowed in low-emission zones and town centres.<br><br>Travel over longer distances is facilitated by a dense network of public transport. Educational programmes aimed at improving IT skills have facilitated the use of mobile applications for public transport. With these applications individuals can plan the best route and have information in real-time on the location of the bus, so that they can plan their journey more effectively. |
| Questions:<br><br>What interventions can help achieve this scenario?<br>How can these interventions be combined with other policies that help to increase their effectiveness, acceptability and feasibility?<br>What time frames should be used for their implementation? (Short 2021-2030; Medium 2030-2040; Long 2040-2050).<br>Who are the key actors for implementation? (Local governance, national government?) |
| **Scenario 3** |
| This future focuses on an improved urban design that prioritises active travel over other forms of transport. A network of interconnected greenspaces with paths which are wide, safe and free from obstructions facilitates active travel such as walking.<br><br>The urban community is well aware about the health benefits of active travel over other modes of transport. Tax benefits are in place for those who chose to travel using active modes of travel including walking and the (electric) bicycle. Low-emission zones and parking taxes mean that the use of cars is greatly discouraged. Signs along walking paths which show actual distances between localities provide pedestrians with the knowledge about the actual distances and the best route they need to take.<br><br>Buses are available at the periphery of this new urban plan and they run on separate lanes than those used for walking or cycling. Buses connect towns together allowing for travel over longer distances. A dense network of public transport provision means that the buses run on time and are frequent and can compete with the efficiency offered by the car. Inside the towns, autonomous electric shuttles are available, and these are connected to the bus system. This system of autonomous shuttles allows for people to carry out other activities such as social activities, carrying of goods from food stores and other work-related activities. |
| Questions:<br><br>What interventions can help achieve this scenario?<br>How can these interventions be combined with other policies that help to increase their effectiveness, acceptability and feasibility?<br>What time frames should be used for their implementation? (Short 2021-2030; Medium 2030-2040; Long 2040-2050).<br>Who are the key actors for implementation? (Local governance, national government?) |

# Appendix G: Phase 4 – Policy packaging
# List of identified policy options

| | **Policy Measure** |
|---|---|
| 1 | A 50% tax increase on fossil fuel |
| 2 | 35% subsidy on purchase of electric cars |
| 3 | A 25% subsidy on capital investments of high speed train transport |
| 4 | Emission norms and car wrecking schemes |
| 5 | Awareness raising campaigns |
| 6 | Investment in road infrastructure |
| 7 | Walking and cycling measures |
| 8 | Reduction in number of empty loads |
| 9 | Hybrid and electric vehicle for urban delivery |
| 10 | Mandatory green travel plans |
| 11 | Road pricing |
| 12 | Decrease of speed limits |
| 13 | National public transport information service |
| 14 | Functional arterial network and nodes for public transport |
| 15 | Decrease of public transport fees |
| 16 | More strategic planning model to integrate land use, housing and transport |
| 17 | Vehicle efficiency standard |
| 18 | Feebates as financial incentives |
| 19 | Parking pricing |
| 20 | Pricing road use |
| 21 | Land use development mix in which homes, jobs and shops are placed close together |
| 22 | Parking standards for new developments |
| 23 | Individualised marketing campaign to promote active travel |
| 24 | Flexible working hours |
| 25 | Teleworking |
| 26 | Travel plans |
| 27 | Increased electrical vehicle charging infrastructure |
| 28 | New bus routes |
| 29 | Guided bus systems |
| 30 | Additional terminals and interchanges |
| 31 | Cycle route |
| 32 | Pedestrian routes |
| 33 | Pedestrian areas |
| 34 | Traffic management |
| 35 | Intelligent transport systems |
| 36 | Traffic calming measures |
| 37 | Parking controls including controls on duration, entry times and designated users |
| 38 | Car sharing and car clubs |
| 39 | New and modified bus service |
| 40 | Bus priorities |
| 41 | Changes in bus frequencies |
| 42 | Bus service management designed to improve reliability |
| 43 | Cycle lanes and priorities |
| 44 | Cycle parking provision |
| 45 | Pedestrian crossing |
| 46 | Safe routes to school |
| 47 | Real-time information systems and route guidance |
| 48 | Parking guidance and information systems |
| 49 | Trip planning systems which provide information on alternatives before the start of the journeys |

| | |
|---|---|
| 50 | Direction signs to encourage walking |
| 51 | Tactile footways |
| 52 | Urban road charging including area licensing and road pricing |
| 53 | Vehicle ownership taxes |
| 54 | bus fare structures such as flat fares, zonal fares and monthly passes |
| 55 | Concessionary fares |
| 56 | Infrastructure for EV charging points |
| 57 | Provide real-time information about bus travel compared with car |
| 58 | Park and ride facilities |
| 59 | High occupancy vehicle lanes |
| 60 | Awareness raising campaigns |
| 61 | Individualised travel planning |
| 62 | Improved efficiency of conventional vehicles |
| 63 | New fuels |
| 64 | Smart vehicles |
| 65 | Distance learning |
| 66 | License fee based on fuel efficiency |
| 67 | Mixed use development |
| 68 | Pedestrian, bike-friendly development |
| 69 | Bicycle facilities connected to bus |
| 70 | Preserve green heat of region |
| 71 | Undergrounds roads and parking |
| 72 | Redevelop centres to recognize cultural and social importance |
| 73 | Integrated multi-modal level information |
| 74 | Integrated ticket system |
| 75 | Route planner for cyclists |
| 76 | Provision of bus to retail |
| 77 | Cycle racks in supermarket |
| 78 | Demand responsive transport |
| 79 | Reduce free car parking |
| 80 | Provide garaged car park close to public transport interchanges |
| 81 | Bicycle racks at bus terminals |
| 82 | Mixed-use development |
| 83 | Location of bus stops close to employment centres |
| 84 | Wider and better maintained cleaner pavements |
| 85 | Regular cleaning of streets |
| 86 | Improved street furniture such as trees, benches - to make walking more pleasant |
| 87 | Safe crossings with shorter waiting times especially arounf schools and offices |
| 88 | Mandate of obligatory shower and locker facilities at work place |
| 89 | Safety cycle training for school children |
| 90 | Bicycle repair workshop |
| 91 | Lower speed limits |
| 92 | Grid layouts |
| 93 | Emphasis on vulnerable road users in license exams |
| 94 | Increase network of bike sharing |
| 95 | R&D subsides to encourage the development of new technologies |
| 96 | Introduction of low carbon fuels |
| 97 | Personal emission credits |
| 98 | Investment in road infrastructure |
| 99 | Reduction in the number of empty loads |
| 100 | Increase in energy efficiency of vehicles |
| 101 | Improved public transport network with electrical powered vehicles |