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Políticas de Mobilidade para um
Desenvolvimento Sustentável

Mobility Policies for Sustainable Development



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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia Civil, realizada sob a orientação científica do Doutor Joaquim Miguel Gonçalves Macedo, Professor Auxiliar do Departamento de Engenharia Civil da Universidade de Aveiro, com a coorientação da Doutora Maria Fernanda da Silva Rodrigues, Professora Auxiliar do Departamento de Engenharia Civil da Universidade de Aveiro.

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palavras-chave

Objetivos de Desenvolvimento Sustentável, Mobilidade Urbana Sustentável, Planos de Mobilidade Urbana Sustentável, Intermodalidade, Mobilidade Integrada, Plano de Mobilidade Urbana Sustentável de Aveiro, Plano Intermunicipal de Mobilidade de Transportes da Região de Aveiro, *Mobility as a Service*

resumo

A presente dissertação surge da necessidade de tornar os hábitos das populações mais sustentáveis, inclusive os seus movimentos diários. Assim sendo, as políticas existentes e serviços devem proporcionar ao utilizador o movimento necessário no seu dia-a-dia, valorizando o impacto ecológico.

A dissertação tem como objetivo analisar as existentes políticas globais e europeias para o desenvolvimento sustentável e mobilidade urbana sustentável, e entender a sua aplicabilidade no nível local. O caso de estudo é a cidade de Aveiro, uma cidade de dimensão mediana, situada na região centro de Portugal. Esta cidade apresenta um nível muito elevado de utilização do carro particular e, através desta análise, é pretendido avaliar se os Planos de Mobilidade Urbana vão ao encontro com o pretendido aos níveis global e europeu.

Assim sendo, começou por se analisar a Agenda para Desenvolvimento Sustentável definida pelas Nações Unidas para a ser atingida no ano 2030. Seguidamente, foi analisado o *White Paper* de 2011 – “*Road to a Single European Transport Area*” da Comissão Europeia e as diretivas da União Europeia para o desenvolvimento de Planos de Mobilidade Urbana Sustentável. Adicionalmente, foram analisados os aspetos socioeconómicos que definem a população em Aveiro, tal como os movimentos pendulares dos cidadãos que vivem na cidade e que trabalham na mesma. Por fim, prossegue-se com uma avaliação do Plano de Mobilidade Urbana Sustentável de Aveiro e o seu enquadramento nas políticas anteriormente analisadas.

Em conclusão, Aveiro apresenta uma estratégia em concordância com as diretivas europeias e os Objetivos de Desenvolvimento Sustentável. Para fortalecer as já existentes políticas, é proposto um modelo de *Mobility as a Service* para a cidade.

keywords

Sustainable Development Goals, Sustainable Urban Mobility, Sustainable Urban Mobility Plans, Intermodality, Integrated Mobility, Plano de Mobilidade Urbana Sustentável de Aveiro, Plano Intermunicipal de Mobilidade de Transportes da Região de Aveiro, Mobility as a Service

abstract

The present dissertation was built from the need to increase sustainability in the populations' habits, including their commuting habits. The existing policies and services should provide the user with the needed mobility without compromising the environment.

The dissertation aims at analysing the existing global and European policies for sustainable development and sustainable urban mobility, and at understanding their applicability at the local level. The case of study is the city of Aveiro, which is a mid-sized city situated in the Centre Region of Portugal. This city presents a high level of private car use and this analysis aims at evaluating if the Urban Mobility Plans are aligned with the proposed at the global and European levels.

Thus, the 2030 Agenda for Sustainable Development of the United Nations was analysed. Then, the 2011 White Paper – “Road to a Single European Transport Area” of the European Commission and the Sustainable Urban Mobility Plans' Guidelines of the European Commission were analysed. Moreover, the analysis of the socio-economic factors of Aveiro was pursued, as well as the commuting habits of the citizens living and working in the city. Finally, Aveiro's Sustainable Urban Mobility Plan was evaluated, as was its fitting into the aforementioned global and European policies.

In conclusion, Aveiro presents a strategy aligned with the European policies and the Sustainable Development Goals. In order to empower the existing local policies, a model of Mobility as a Service is proposed.

“look at what they’ve done
the earth cried to the moon
they’ve turned me into one entire bruise” – green and blue

“The Sun and Her Flowers”, Rupi Kaur

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Acronyms

API	Application Programming Interface
BUGA	Bicicleta de Utilização Gratuita de Aveiro
CCT	Centro Coordenador de Transportes
CIRA	Comunidade Intermunicipal da Região de Aveiro
CP	Comboios de Portugal
DaaS	Data as a Service
DG-CLIMA	Directorate-General for Climate Action
DG-MOVE	Directorate-General for Mobility and Transport
DG-TREN	Directorate-General for Transport and Energy
EEA	European Environment Agency
ERDF	European Regional Development Fund
EU	European Union
FaaS	Fleet as a Service
GDP	Gross Domestic Product
GHG	Greenhouse gas
GM	Great Manchester
IaaS	Inr
ICT	Information and Communication Technology
IMT	Instituto de Mobilidade e dos Transportes, I.P.
MaaS	Mobility as a Service
PEDUCA	Plano Estratégico de Desenvolvimento Urbano da Cidade de Aveiro
PIMT-RA	Plano Intermunicipal de Mobilidade e Transportes da Região de Aveiro
PMMA	Plano de Municipal de Mobilidadede Aveiro
PMUSA	Plano Mobilidade Urbana Sustentável de Aveiro
SDG	Sustainable Development Goal
SloCaT	Partnership on Sustainable, Low Carbon Transport
SMART	Specific, Measurable, Attainable, Relevant, Time-bound
SUMP	Sustainable Urban Mobility Plan
TaaS	Transport as a Service
TfGM	Transport for Great Manchester
WCED	World Commission on Environment and Development

Chapter 1

Introduction

1. Introduction

Nowadays, the planet is facing a great challenge – the population is consuming the land's resources at high pace and, from that consumption, it is producing harmful consequences for the planet's inhabitants. Not only the future generations are being threatened, as currently the peoples of the world are already feeling them. In order to guarantee the generations to come have a planet to live in, sustainable development must be a priority. Therefore, the daily habits of each person must be reviewed and turned into creating no harm. Transportation is one of the fields that contribute to climate change, which is one of the biggest emergencies of today. Consequently, this dissertation aims at exploring the already existing policies and understanding the path humanity must take in order to make their movement as environmentally friendly as possible.

Failed actions towards climate change are one of the risks identified by the World Economic Forum (World Economic Forum, 2019). In 2016, 195 members of the United Nations Framework Convention on Climate Change signed the Paris Agreement. This agreement sets a commitment on keeping the increase of global average temperature bellow 2°C when comparing with the pre-industrial levels and to pursue efforts on keeping it bellow 1.5°C, on increasing the adaptability of the planet towards climate change effects, foster climate change resilience, lower greenhouse gas (GHG) emissions without prejudicing food production, and on making finance pathways consistent with low greenhouse gas emissions and climate change resilience developments (United Nations, 2015).

Transportation plays a key-role in the GHG emissions share – according to the data of European Environment Agency (EEA) in 2014, it represents 19.5 per cent of the total quantity of emissions (DG-CLIMA, 2014). From that share, road transportation is responsible for 71.7 per cent (European Environment Agency, 2017). In Portugal, in the year of 2016, 28.1 per cent of the GHG emissions of the country were caused by transportation (DG MOVE, 2018). These values represent an incompatible behaviour to achieving the 2030 Agenda for Sustainable Development (United Nations, 2019a). Thus, this dissertation aims

at reflecting on the current policies that exist for urban transportation at the local level and how they are inserted in the global and European framework, to provide a solution or next steps on how to adapt our current urban situation for sustainable development. For the analysis, the selected documents were the 2030 Agenda for Sustainable Development of the United Nations, for the global framework, and the 2011 White Paper of the European Commission, for the European level.

Aveiro is a mid-sized city in the Centre Region of Portugal. Aveiro faces a high number of private car users, which does not contribute for environmentally friendly lifestyles. This city faces one of the predominant problems of urban transportation planning, which is urban sprawl. The city is the case of study for this dissertation, since it is one accurate example of the problems governments and civil society faces when planning urban mobility and implementing it. Having in mind the mobility behaviours of Aveiro's population, answers must be given to our planet, without underestimating the population's needs. Hence, the population of Aveiro, the socioeconomic background, the ageing, the commuting behaviours and, as well, the generation of business in the city are analysed in the present document. The populations around Europe are, generally, very dependent on the private vehicle use and Aveiro is not an exception.

In order to answer to the city's needs and acknowledge the importance of the environment, different existing measures were taken into consideration and analysed, such as the usage of active mobility and the concept of Mobility as a Service.

1.1. Motivation

Reflecting on the issues that the planet is currently facing, the theme of this dissertation came from an analysis of the role societies, policy and engineering have to play in order to make the planet more sustainable and without compromising future generations. Transport, besides providing exchange and movement of goods and people, is one of the tools that must be thought thoroughly in order to turn it into a more efficient tool, user and environment-friendly.

Sustainable Urban Mobility is a field that has started to be more explored, to provide faster, easier and greener movement to the peoples of the world. In order to answer the users' needs and the planet's needs, Sustainable Urban Mobility is analysed in this dissertation and which policies are there to support it, as in the international, European and local levels. And, by the end, a possible tool to empower Sustainable Urban Mobility is proposed.

This dissertation was created from the need to find a way in which people can live their own wished lives, without compromising the future generations' freedom.

1.2. Goals

In order to achieve a thorough and pertinent analysis of the policies for sustainable development and to provide a relevant analysis of their application at the local level, different goals were set. In this point, it is possible to set those goals, aligned with what was mentioned above in the Introduction. They are as follows:

- Analyse the 2030 Agenda for Sustainable Development and its correlation with transportation;
- Analyse the 2011 White Paper of the European Commission and European directives for Sustainable Urban Transportation;
- Analyse the Sustainable Urban Mobility Plans guidelines;
- Analyse practices for Sustainable Urban Mobility;
- Analyse demographically the city of Aveiro and its commuting patterns;
- Analyse the Strategic Plans, for the city and region, such as the Intermunicipal Mobility and Transport Plan of the Region of Aveiro (PIMT-RA) and the Sustainable Urban Mobility Plan of Aveiro (PMUSA) and their connection to the Sustainable Development Goals;
- Propose a concept in order improving the sustainability of urban mobility in Aveiro;
- Reflect on the ongoing strategic plans of the city.

1.3. Structure

The document is divided into five chapters, composing the dissertation. The division of the chapters aims at, firstly, providing a context of the existing policies, providing the context of the current situation of Aveiro, and then to analysing the local level policies and how they are aligned with the global and European ones, and how to empower them. The chapters have the following purposes:

- Chapter 1: consists on the introduction of the dissertation;
- Chapter 2: consists on the state-of-art of Sustainable Urban Mobility, policies supporting it and to the introduction of good practices of sustainable urban mobility;
- Chapter 3: demographic and economic analysis of Aveiro, and as well to the commuting present in the city;
- Chapter 4: dedicated to the analysis of the strategic documents for mobility of both Aveiro and the region of Aveiro, and further connection between the actions of the Sustainable Urban Mobility Plan of Aveiro and the Sustainable Development Goals (which are influenced by Transportation, as presented in chapter 2), and to a small adaptation of Mobility as a Service for Aveiro;
- Chapter 5: contains the final remarks of the dissertation and future developments of the present research.

Chapter 2

Sustainable Urban Mobility

2. Sustainable Urban Mobility

In order to pursue this dissertation, it is crucial to understand the meaning of sustainable development and the role of transportation in it. For a world with no compromised future generations, sustainable mobility plays a crucial role, by providing citizens the right tools and networks to pursue their movements without harming the planet. Building on that, mobility does play a vital role in the cities' functioning and the daily lives of the citizens living and working in them, and so it is undoubtedly necessary. The needed resources and services of mobility are constantly increasing with the economy and the mobile habits of the active generation. Therefore, urban mobility can have a harmful role in the planet's sustainability, due to the increasing need of answering to different mobility behaviours and the consequent increase in the usage of energy. Sustainable Urban Mobility strengthens the link between land and transport (David Banister, 2008).

Moreover, in the present chapter, the role of Transport in the Sustainable Development Goals will be tackled as well as the policies implemented by the European Union. Afterwards, some good practices from around Europe will be shared. This approach fosters the creation of a state-of-art of the existing policies at the global and European level, so it is possible to further explore their applicability at the local level.

2.1. Sustainable Development

Sustainable Development is a broad concept, as it is possible to see by Herman Daly's reflection: *"Exactly what is it that is supposed to be sustained in 'sustainable' development? Two broad answers have been given: First, utility should be sustained; that is, the utility of future generations is to be non-declining. The future should be at least as well off as the present in terms of its utility or happiness as experienced by itself. Utility here refers to average per capita utility of members of a generation. Second, physical throughput should be sustained, that is, the entropic physical flow from nature's sources through the economy and back to nature's sinks, is to be non-declining. More exactly, the capacity of the ecosystem to sustain those flows is not to be run down. Natural capital is to be kept intact."*

The future will be at least well off as the present in terms of its access to biophysical resources and services supplied by the ecosystem. Throughput here refers to total throughput flow for the community over some time period (i.e., the product of per capita throughput and population)” (Daly, 2016).

For the present work, the definition utilised is the definition by the World Commission on Environment and Development (WCED) of 1987: “*Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” (World Commission on Environment and Development, 1987).

2.1.1. Sustainable Development Goals

At the United Nations Headquarters in New York, from the 25th to the 27th of September of 2015, with the celebration of the Organisation seventieth birthday, the Heads of State and Government and High Representatives have decided on the new universal Sustainable Development Goals (Figure 1). The implementation of these Goals and targets started on the 1st of January of 2016 (United Nations, 2015b).



Figure 1 - Sustainable Development Goals (United Nations, 2015b)

The United Nations saw the need to “*free the human race from tyranny of poverty*” and “*to heal and secure our planet*”. For that purpose, it was created the “*Transforming our world: the 2030 Agenda for Sustainable Development*”. This universal Agenda is constituted by 17 Sustainable Development Goals and 169 targets. Its purpose is to respond to the peoples and

the planet needs, in a fair, equal and accessible approach, completing what the Millennium Development Goals could not reach (United Nations, 2015b).

All the Sustainable Development Goals and targets are defined and integrated on the three dimensions of sustainable development: the economic, the social and the environmental dimension. It is important to highlight the need to have the three dimensions all connected and taken into consideration since they are the fundamental aspects for real sustainable development of the planet Earth's system (United Nations, 2015b).

The Goals and targets defined by the Agenda were set considering two years of consultation, engaging society and stakeholders around the globe. Hence, it is important to refer that the consultation received a lot of contribution from the Open Working Group of the General Assembly on Sustainable Development Goals and from the United Nations (United Nations, 2015b).

The vision provided by the United Nations in the Agenda lies on the importance of a safe environment for all: all human rights are fulfilled - the right to have food and water, healthcare, quality education, safety and justice, besides each individual background, gender, nationality and religion (United Nations, 2015b).

During the elaboration of the Agenda, the respect for the national policies and for the ways of governance is strongly present. The respect for the different backgrounds, especially concerning developing regions, promotes a more flexible and productive environment when developing all the areas in a sustainable way. The approaches in each region, including each policies framework, will result in more effective and healthier implementation of the Agenda. This inclusion will promote a more sustainable development of the economy in each region, making the financial status of the different countries more stable (United Nations, 2015b).

Here presented is the list of the 17 Sustainable Development Goals presented by the United Nations in the 2030 Agenda for Sustainable Development (United Nations, 2015b):

- *“Goal 1: End poverty in all its forms everywhere*
- *Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture*
- *Goal 3: Ensure healthy lives and promote well-being for all at all ages*
- *Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all*
- *Goal 5: Achieve gender equality and empower all women and girls*
- *Goal 6: Ensure availability and sustainable management of water and sanitation for all*
- *Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all*
- *Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all*
- *Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*
- *Goal 10: Reduce inequality within and among countries*
- *Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable*
- *Goal 12: Ensure sustainable consumption and production patterns*
- *Goal 13: Take urgent action to combat climate change and its impacts*
- *Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development*
- *Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*
- *Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels*
- *Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development”*

In the Sustainable Development Goals Report 2019, it is stated that the need for the Governments and Stakeholders commitment is crucial. The report shows the progress is too slow to accomplish the goals set for 2030 (United Nations, 2019b).

2.1.2. Sustainable Development Goals and Transport

Even though transport does not have a dedicated Sustainable Development Goal in the 2030 Agenda for Sustainable Development, its impact is clear. Transport contributes to the implementation of the SDGs, with a direct and indirect approach (Technical Working Group on Transport, 2015). In Figure 2, it is possible to see which SDGs transport is connected to, and the direct and indirect connection to their targets (SloCaT, 2015).

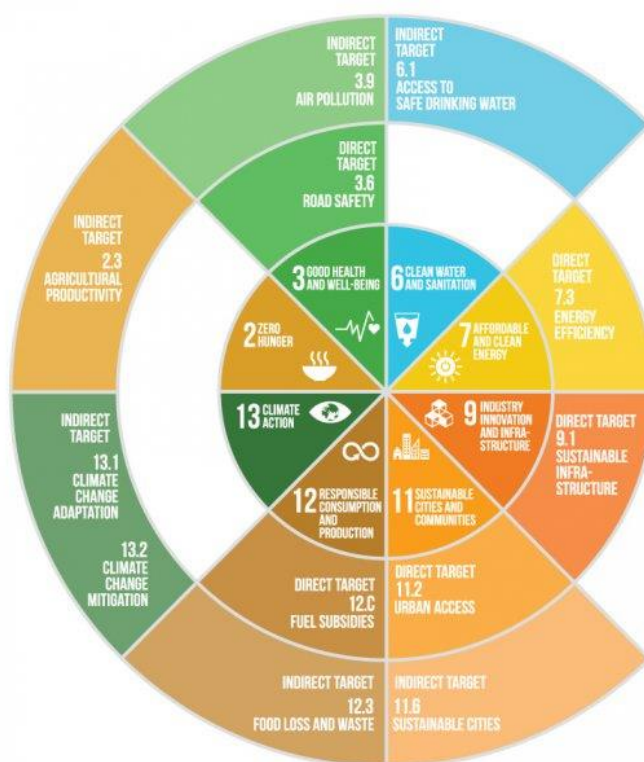


Figure 2 - Relation between Transport and UN SDGs and Targets (SloCaT, 2015)

It is very important to acknowledge that, to advocate for sustainable development, transport and urban mobility cannot be forgotten. Transport, besides having a big impact on the carbonization of our environment and, with this, climate change, it provides access to the most basic needs of the populations: food, water, health care and education. Safe and resilient transport aims to provide a secure society for all, decreasing the number of road accidents and increasing safety for all, including women, children and indigenous. Transport has a strong impact on the socio-economic development of a society: creating new job offers and positions; ensuring movement of goods, within and across borders; sustainable transport can

be a more affordable option to access jobs, schools, markets and health care; sustainable transport promotes friendly-environment behaviours, providing a low-carbon development pathway (Technical Working Group on Transport, 2015). In Figure 2, it is possible to observe the different connections between Transport, the SDGs and their targets. They can be connected directly and indirectly. For further clarification, in Table 1 the SDGs and Targets that are directly connected with Transport can be found. In Table 2 the SDGs and Targets that are indirectly connected with Transport can be found.

Table 1 - Direct connection between Transport, SDGs and their targets

SDGs and targets directly connected with Transport	
SDGs	Targets
SDG 3	“3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents.”
SDG 7	“7.3 By 2030, double the global rate of improvement in energy efficiency.”
SDG 9	“9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.”
SDG 11	“11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.”
SDG 12	“12.C Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.”

Table 2 - Indirect connection between Transport, SDGs and their targets

SDGs and targets indirectly connected with Transport	
SDGs	Targets
SDG 2	“ 2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.”
SDG 3	“ 3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.”
SDG 6	“ 6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all.”
SDG 11	“ 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.”
SDG 12	“ 12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.”
SDG 13	<p>“13.2 Integrate climate change measures into national policies, strategies and planning.”</p> <p>“13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.”</p>

Regarding the energy sector, renewable energy is having a substantial focus nowadays and the progress was compared for the heat and transport sectors. The share of renewable energy globally has increased from 17.5 per cent in 2010 to 18.3 per cent in 2014, in final energy consumption. The most considerable growth has happened in the electricity sector (United Nations, 2017).

The point of action to expand renewable energy will be to increase its share in heat and transport, that together count with 80 per cent of energy consumption (United Nations, 2017). In 2012, transport was the largest energy-consuming sector in 40 per cent of countries in the world (SloCaT, 2015). Besides the fact that the share of renewable in the heat sector increased from 25.7 per cent in 2010 to 26.3 per cent 2014, the share of renewable energy in the transport sector stayed extremely low: 2.8 per cent in 2014. Globally, primary energy intensity decreased by 2.1 per cent in a year, from 2012 to 2014 (United Nations, 2017).

During that period, three-quarters of the world's 20 largest energy-consuming countries decreased their energy intensity. However, the savings associated with the reduction were equivalent to the total energy spent by Brazil and Pakistan together in 2014 (United Nations, 2017).

Industry and passenger transport sectors had a contribution to the reduction of global energy intensity with annual reductions of 2.2 per cent in industry and 2.8 per cent in passenger transport. Regarding the transport sector, the overall spread diffusion of fuel-efficiency standards accelerated the reductions in energy intensity, especially in passenger transport (United Nations, 2017).

The connections provided by transportation, with the movement of goods, inside of a country of cross borders, drives a substantial impact on the economy. In 2015, the global economic impact, direct and indirect, of air transport was approximately 2.7 trillion US dollars, 3.5 per cent of global gross domestic product (GDP). The most predominant way of freight transportation is road transport, accounting with 61 per cent in total, globally. Road transportation is the most predominant in passenger transport as well (United Nations, 2017).

2.2. Europe and Urban Mobility

Transport is what makes communities be active, by going to their jobs, and pursuing health, educational, cultural and economic services. It is safe to say that, besides being environmentally friendly, mobility policies should acknowledge competitiveness, offering accessible, affordable and fast services, contributing to the populations' well-being and considering the planet's limitations. Urban mobility is a topic that concerns all inhabitants. Nine in ten European Union citizens believe mobility practices should be improved (European Commission, 2007). In this part, the policies and directives from the European Union will be analysed, in order to build a bridge from the global to the European level, and understand their connection.

Transport services are not supporting all - the surroundings usually do not experience efficient services, making those areas less accessible and, consequently, less attractive, considering the lack of accessibility promotes the decrease of services and their development, fostering exclusion and isolation of inhabitant communities. To coordinate local and city-regional level must be a focus point, the development of sustainable urban mobility must approach cities and rural areas with the same importance and create partnerships. When developing policies and making decisions, cities should not be isolated but integrated into a broader scenario (European Commission, 2011). Nevertheless, attention should be paid to deprived neighbourhoods, making those more accessible and fairer, fighting against social exclusion, by giving them equal opportunities for efficient and affordable public transport systems and, consequently, providing the same mobility of other citizens. *“The better we manage to stabilize deprived neighbourhoods economically, to integrate them socially and to upgrade their physical environment and transport infrastructure, the better the chances are that our cities will remain places of social progress, growth and innovation in the long term”* (European Union, 2007). Urban sprawl promotes the increase of energy consumption and cities' congestion. The lack of integrated transport services for the population results in the increased use of private cars since it is too difficult and expensive to implement public transport due to the low population density. Moreover, urban sprawl promotes spatial segregation and social exclusion. The distance to

basic services (e.g. education) and the insufficient and non-integrated public transport to different services make it hard for people that cannot own or use a car, and the alternatives such as walking, cycling and taking public transport are non-existing, to move inside the city.

Urban transport should promote accessibility, with a coordinated and a fair price it fosters the quality of life, by improving environmental issues and the population's health. Increasing collective transport, with minimum service requirements, will promote the adherence of inhabitants to it and, consequently, will increase its density and frequency (European Union, 2007). Traffic management, land-use planning and interlinking transport modes can lower traffic volumes, promoting radical changes in congestion, air pollution and noise exposure, including providing cycling and pedestrian infrastructure part of urban mobility plans can be the key (European Commission, 2011).

Climate change is one of the most urgent responsibilities of the cities of today and tomorrow and sustainable mobility is one of the actions that cities must take when it comes to the reduction of CO₂ emissions and resource-efficiency measures. Greener practices bring a lot of benefits for cities: air quality, the decrease in traffic congestion, the increase of populations' health. Fostering the use of non-motorised mobility would reduce air pollution and increase general health and fitness of the inhabitants, as the reduction of congestion would bring economic benefits, promoting everyone's efficiency. Urban transport creates approximately a quarter of CO₂ emissions from the transport sector.

The target set by the European Commission in the 2011 White Paper for the transport sector is the reduction of emissions in 60 per cent from 1990 to 2050. The transport industry plays an essential role in the economy – inside the European Union, the sector employs around 10 million people and accounts for approximately 5 per cent of GDP. Building on that, and in order to provide member states with the due tools, the European Commission developed guidelines for developing Sustainable Urban Mobility Plans (SUMP), so countries could have a uniform and efficient basis to develop their own plans. In the next point, the guidelines of SUMP will be thoroughly analysed, in order to provide a framework on which the next chapters will be sustained.

2.2.1. Sustainable Urban Mobility Plans (SUMPs)

“A Sustainable Urban Mobility Plan is a strategic plan designed to satisfy the mobility needs of people and businesses in cities and their surroundings for a better quality of life. It builds on existing planning practices and takes due consideration of integration, participation, and evaluation principles” (Wefering, Rupprecht, Buhrmann, & Bohler-Baedecker, 2013).

A Sustainable Urban Mobility Plan is envisioned to create an urban transport system addressing, at least, the following goals (Wefering et al., 2013):

- Guarantee transport options for citizens to access the main destinations and services;
- Reduce pollution, air and noise, greenhouse gas emissions and energy consumption;
- Improve safety;
- Improve efficiency and cost-effectiveness of transportation for people and goods;
- Contribute to increase the attractiveness of the cities and quality of the urban environment and design for the benefits of the citizens, economy and society.

In figure 3, the planning cycle of a SUMP is divided into four phases and eleven steps, according to the guidelines launched by the European Commission (European Commission, 2017).

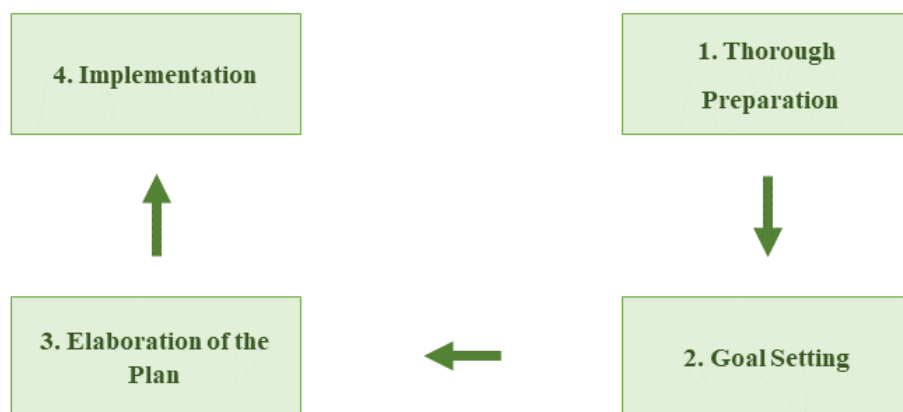


Figure 3 - SUMP Phases (Wefering et al., 2013)

2.2.1.1.Phase 1: Preparation

The preparation phase aims to understand how successful a SUMP could be in the city under evaluation. It is crucial to understand and ensure the basis of sustainable mobility, evaluate the present scenario and define the future approaches to timeline, policy and stakeholders. In Table 3, there are the steps and activities of phase 1 (Wefering et al., 2013).

Table 3 - Steps and Activities of Phase 1

Steps	Activities
1. Determine the potential for a successful SUMP	1.1. Commit to sustainable mobility principles; 1.2. Assess the impact of regional/national frameworks; 1.3. Conduct self-assessment; 1.4. Review the availability of resources; 1.5. Define basic timeline; 1.6. Identify key actors and stakeholders.
2. Define the development process and plan scope.	2.1. Look beyond your boundaries and responsibilities; 2.2. Strive for policy coordination and an integrated planning approach; 2.3. Planning of the stakeholders and citizens' involvement; 2.4. Definition of work plan and management arrangements.
3. Analyse the mobility situation and develop scenarios	3.1. Prepare an analysis of problems and opportunities; 3.2. Develop scenarios.

2.2.1.2. Phase 2: Goal Setting

The second phase is dedicated to the definition of the goals for the plan. To set these goals, there is the need to understand the vision of the citizens and how to engage them, to define them and connect measurable targets and to develop the measures. In Table 4, there are the steps and activities of phase 2 (Wefering et al., 2013).

Table 4 - Steps and Activities of Phase 2

Steps	Activities
1. Develop a common vision and engage citizens	1.1. Develop a common vision of mobility and beyond; 1.2. Actively inform the public;
2. Set priorities and measurable targets	2.1. Identify the priorities for mobility 2.2. Develop SMART targets
3. Develop effective packages of measures	3.1. Identify the most effective measures 3.2. Learn from others' experience 3.3. Consider best value for money 3.4. Use synergies and create integrated packages of measures

2.2.1.3. Phase 3: Elaboration of the plan

The third phase is dedicated to the actual elaboration of the Sustainable Urban Mobility Plan. Firstly, there is the allocation of funding and responsibilities. Then, determine how to monitor and assess the plan. And, finally, the adoption of the plan. In Table 5, there are the steps and activities of phase 3 (Wefering et al., 2013).

Table 5 - Steps and Activities of Phase 3

Steps	Activities
1. Agree on responsibilities and the allocation of the funding	1.1. Assign responsibilities and resources 1.2. Preparation of an action and budget plan
2. Build monitoring and assessment into the plan	2.1. Arrange for monitoring and evaluation
3. Adopt Sustainable Urban Mobility Plan	3.1. Check the quality of the plan 3.2. Adopt the plan 3.3. Create ownership of the plan

2.2.1.4.Phase 4: Implementation

Phase 4 is focused on the implementation. The plan has to be properly managed and the communication with the local community has to flow smoothly. Then, during this phase, the plan should be continuously evaluated and, when needed, updated. Besides, the continuous evaluation will show future challenges for next SUMPs. In Table 6, there are the steps and activities of phase 4 (Wefering et al., 2013).

Table 6 - Steps and Activities of Phase 4

Steps	Activities
1.Ensure proper management and communication	1.1.Manage plan implementation 1.2.Inform and engage citizens 1.3.Check progress towards achieving the objectives
2.Learn the lessons	2.1.Update current plan regularly 2.2.Review achievements – understand success and failure 2.3.Identify new challenges for next SUMP generation

2.3. Sustainable Urban Mobility in mid-sized cities

After analysing the existing guidelines and policies for sustainable urban mobility, this point sets a brief basis for mobility in mid-sized cities, such as Aveiro, the case of study of this dissertation.

Urban Mobility is a challenge in mid-sized cities, where the population density is higher in the municipality than in the surroundings. Additionally, with the consequent concentration of the services (health, education, financial, administrative) in the small urban space, resulting in congestion of the traffic, air pollution and noise pollution. Facing this, urban planning presents a vital aspect in order to achieve sustainable urban transportation systems (Ribeiro & Mendes, 2013).

Sustainable Urban Mobility plays a vital role in Smart Cities. Smart Cities are cities in which the investments in human and social capital, infrastructure and technology foster sustainable economic growth and quality of life, ensuring a sustainable management of natural resources, through involvement of all parties (Deloitte The Netherlands, 2015). Sustainable Urban Mobility policies and measures will not achieve their goals if citizens do not become aware of their importance and how common health and well-being will benefit from it, and consequently changing their behaviour (Kazhamiakin et al., 2015).

In the next point, some of the main measures for Sustainable Urban Mobility will be explained and some practices already shown, and it will be possible to observe they are possible practically, not only in theory.

2.4. Measures for Sustainable Urban Mobility

Sustainable Urban Mobility has been translated into different actions around the globe. In this part, it will be showed the main measures for it and some practical examples already taking place around Europe.

When designing Sustainable Urban Mobility strategies, it is clear that in order to reduce the arm caused by transportation to global warming, the key point is to decarbonise transport. The GHG emissions depend on various factors such as the kilometres pursued to go to one point to another, the energy consumption and the intensity of CO₂ emissions of the energy resources used for the movement. Therefore, when facing these three factors, there are different measures that can be implemented and foster the decrease of GHG emissions and event have transportation modes with zero emissions. Following on that, the previous measures can act in different parts of the problem, such as in the reduction of the pursued kilometres, the decrease of energy consumption through modal shift and as well the decrease on the intensity of CO₂ emissions, through renewable energy (VTT, 2014).

Measures on the aforementioned three factors are possible to turn into a reality, as it is possible to see in the next points with urban planning, congestion charging, active mobility, local public transportation, shared mobility, alternative energy sources and Mobility as a Service.

2.4.1. Urban Planning

Urban planning plays a key-role in sustainable mobility (Hickman, Ashiru, & Banister, 2011). The land use and as well the travel patterns are very complex to analyse and solve, since they are correlated with the population's socioeconomic background (Stead, 1999). Achieving sustainable mobility is a challenge since urban sprawl is a reality in a variety of countries, such as Portugal (Santos, 2012).

In order to mitigate CO₂ emissions, cities must provide the right infrastructures and spatial organisation for their population's movement and activity. Infrastructures for walking, cycling and public transportation needs to connect houses, work, education and services. Transportation modals should be planned as one network.

One example of urban planning for the sustainable mobility is the Great Manchester (GM) Transportation Strategy 2040. This strategy takes into consideration special planning, accommodating the growth Great Manchester is expected to have by 2030 without additional congestion. Thus, GM Transportation Strategy 2040 considers the connectivity and accessibility of work, education and services. It analysed the areas that are well served with public transport, walking and cycling, and as well the areas which are lacking these services and that public transportation can be implemented and used efficiently.

GM Transportation Strategy 2040 places housing and employment close to services and public transportation, enabling travellers to reduce their private car usage: “Policy 4: TfGM will continue to work with planning authorities and developers to ensure the accessibility of new development by sustainable modes and to reduce the impact on the highway network” (TfGM, 2017).

2.4.2. Congestion Charging

Congestion is a reality in a lot of cities around the world and it can be caused by different factors. Drivers utilising main streets daily or seeking for parking in the city centre can influence greatly the congestion of a city. In order to decrease congestion, some charging schemes are being implemented, those being road pricing and parking pricing. Road pricing can be translated into screening off a section on a city centre and imposing a fee to circulate there. While parking pricing can be translated into charging for parking inside or even outside a city centre (Larson & Sasanuma, 2010). With the decrease in congestion, not only time is saved, but emissions of CO₂ decrease as well. In order for this measure to function, alternatives must be offered, such as public transportation or bike-sharing schemes (European Platform on Sustainable Urban Mobility Plans, 2016).

One example of congestion charging is the city of London, that faces severe problems of congestion, therefore the city has implemented both parking and road pricing. About parking pricing, London offers a different set of options for the city centre, depending on which vehicle the user has. The prices for parking 15 minutes go from 1 pound (if it is a hybrid or electric car) to 1.7 pounds – the price increases with the environmental footprint the vehicle can have. Additionally, if the price is per hour it will go from 4 pounds to 6.8 pounds, following the same logic. The first hour of parking is for free. This is applicable from 7 am to 7 pm, in working days, and the schedule can change depending on the area.

Regarding road pricing, the charged area is in the city centre and the authorities are considering expanding the zone, following the same model as Stockholm. There are exemptions to emergency vehicles and vehicles for disabled people, and there are discounts for some type of vehicles such as residents' vehicles, hybrid and electric cars, and vehicles for more than 9 people. This scheme is in place from Monday to Friday, from 7h00 to 18h00 and the price is 11.5 pounds (13.09 euros). The Stockholm congestion charges were introduced in 2006, as a trial, and permanently introduced in 2007. The area under the scheme is the city centre, however, there are exemptions of payment to emergency vehicles, buses, diplomatic vehicles, disabled people vehicles, military vehicles, hybrid or electric cars, motorcycles and mopeds, and foreign-registered vehicles. The amount of payment depends on the time of the day and it is not paid during the weekend, public holidays or the day before a public holiday, and during the night, from 18h30 to 06h29. The maximum amount for one day is SEK 105 (9.67 euro).

2.4.3. Active Mobility

Active Mobility introduces one modal shift towards zero-emissions while commuting. In several cities, this shift is possible, and it can be implemented through the introduction of the right infrastructures and the change of habits of the population.

Pedestrianisation is the act to convert a road for cars and motorised vehicles to become a space for only pedestrians. This act promotes safety while walking and human-power vehicles, such as bicycles, for commuting and, therefore, it promotes active mobility for the citizens' daily lives. Pedestrianisation is directly connected with the decrease of motor

vehicles, and, for this reason, it is safe to say it contributes for the environment – both noise pollution as air pollution decrease considerably in these areas. Having areas where motor vehicles cannot be used, it promotes as well as the usage of public transportation to move to these places (Iranmanesh, 2008).

Bike-sharing systems have been implemented in various countries around the world and the tendency is to increase that number. The system offers the possibility of renting the bike in one place and leaving it in another different station, giving the opportunity to combine different transportation modalities for a more efficient journey. The payment is as well simple, since it can happen online, and it can offer different packages for the user. The introduction of bike-sharing systems aim at creating zero GHG emissions' mobility infrastructures, reduce congestion and providing the population with a well-responsive system to pursue their needed movements (Midgley, 2009).

For example, in Brussels, measures on pedestrianisation were taken. The Anspacht Boulevard became pedestrian in 2015 and constructions to implement that measure are being finalised. One of the main points of attention should be the integrated approach of public transportation around the area and, for this reason, the transformation was possible and successful. Due to this transformation, it was possible to connect the pedestrians existing in the Grand Place, in the Fointane Place and the Brouckère Place to the Anspacht Boulevard. There are several other examples of the implementation of active mobility as one of the commuting modes in different cities. In Portugal, bike-sharing was introduced in several cities, including Lisbon, who faces various challenges in mobility.

2.4.4. Local Public Transportation

Local Public transportation can considerably reduce the congestion within cities and the emissions produced by urban transportation. The congestion and pollution generated by thirty cars are higher than one bus transporting those thirty people. Public transportation can take a big part in the modal shift required in order to reduce carbon emissions (European Commission, 2016). In order to make public transportation an appealing and efficient option

for inhabitants, it must be reliable, accessible, comfortable and affordable, and the system should be integrated with other modalities. Besides, in order to be considered a good system, they should be fast and frequent. High quality public transportation must combine both optimisation of efficiency and attractiveness for the public, meaning, a system with the combination of a lot of passengers and low cost (DG TREN, 2010).

Different cities, such as Brussels, combine successfully different transport modes in their public transportation system, as buses, tram and metro. One of the factors that foster the usage of public transportation in Brussels is the integrated ticketing, meaning when a user buys a single ticket, the user can take a bus, a tram and metro in a journey, using always the same ticket. Besides, public transportation is available constantly, however the modes can change.

Nowadays, in cities such as Madrid and Aveiro, hybrid buses have been included to the public transportation infrastructures, aiming at reducing even more the transportation footprint (CIVITAS, 2019).

2.4.5. Shared Mobility

Shared Mobility refers to the shared use of vehicles, such as cars and bikes, that enables users of having access to those vehicles on short-term mobilities and only when needed. This innovative concept can include both car-sharing and bike-sharing, but as well as ridesharing, where users can carpool, and on-demand ride services (S. Shaheen, N. Chan, A. Bansal, A. Cohen, TSRC, 2015). This concept can reduce the GHG emissions and congestion by optimising routes.

In bike-sharing systems, users access a bike in a as-needed basis, for one -way mobility or roundtrips. These systems provide a variety of pick-up and drop-off points, so routes can be flexible for the user's needs. Car-sharing systems work the same way, in which the users use a car whenever they need. These make the service and the vehicle available for the user, without the ownership of the vehicle and all the costs correlated with it (U.S. Department of Transportation, 2016).

Carpooling follows an alike premise to public transportation, in the fact that instead of using five vehicles for five people for one route, it is only used one vehicle, which makes it much lighter for the environment and certainly less expensive. Regarding on-demand ride services, the impact on the environment is not very clear; however, when it comes to congestion, it can have a true impact.

2.4.6. Alternative energy sources

One of the possibilities in order to decrease the air pollution created by transportation is the adoption of low-emission alternative energy. Eco-driving is as well a way of reducing carbon emissions, introducing different practices to drivers in order to consume less fuel, however it is still dependent of fossil fuel.

Electric cars offer lower pollution, noise, and CO₂ emissions. However, at this moment, it is more expensive than the fossil fuel approach to build electric cars and so their usage is still low (J. Van Mierlo, 2017). Besides, there is still the introduction of hybrid vehicles, which use both electric energy and fuel. These two engines are as well applied for buses, which some cities already started to implement, such as Aveiro. Additionally, biofuel has been introduced as an alternative to fossil fuel and it is any fuel that is derived from biomass. It creates less GHG emissions and it has a competitive cost (K Hanaki, 2018).

2.4.7. Mobility as a Service (MaaS)

Mobility as a Service (MaaS) is a concept that introduces a mobility distribution model which answers to the users' transport needs, through a single service provider, setting a system built on the interconnectivity of transport modes, depending on their availability and the users' demands. MaaS systems' main components are the Information and Communication Technologies (ICTs) (Jittrapirom et al., 2017).

MaaS is the interface of the combined transport systems and, due to its creation, different concepts were created (Figure 4). Transport as a Service (TaaS) would be created since transport companies would have to elaborate on different services to sell them to mobility operators. Transport services are the use of infrastructure, fleet, and data, hence "Infrastructure as a Service" (IaaS), "Fleet as a Service" (FaaS), and "Data as a Service" (DaaS) concepts are created. Due to MaaS, the quantity and quality of data increase, as technology develops and so demand services increases (Heikkil, 2014).

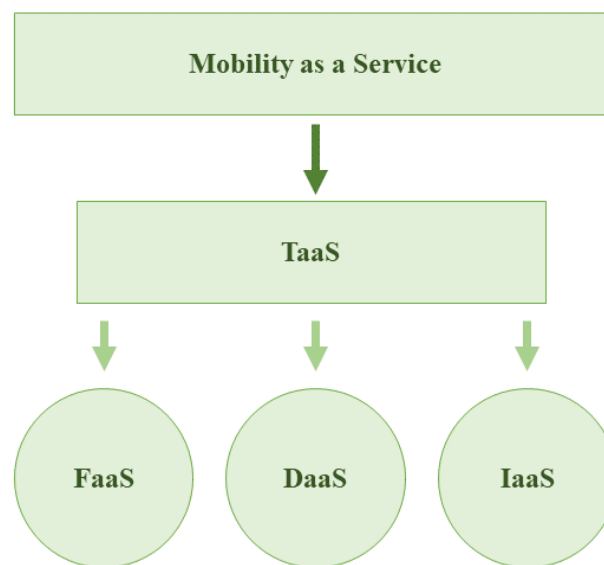


Figure 4 - The connection between MaaS, TaaS, FaaS, Daas, IaaS (Heikkil, 2014)

Therefore, to implement MaaS in a city, some aspects are crucial (Li & Voegelé, 2017):

- Wide range of transport systems available;
- Transport operators with open data for third parties, including their real-time data;
- Transport operators allow another company to sell their service;
- Transport operators offer online sells and online tickets to access their services.

Regarding MaaS at the EU level, despite the proposed in White Paper 2011 on sustainable and smart mobility, no more directives have been released from the European Commission, specifically connected with smart ticketing (Audouin & Finger, 2018).

For the implementation of the above-mentioned concept in Helsinki, a multi-level governance framework was implemented in the metropolitan level, which can present a few challenges due to different governance in the municipalities, different priorities and possible rivalries.

The development of the concept, lobbying and policy-making counted with the contribution of both private and public parties. Hence, parties operating with cross-level activity, with a flexible and adaptable behaviour played a crucial role in the creation of the network, as parties with general-purpose jurisdictions and limited boundaries in their activity made the policy required. For example, a think-tank was built to develop the concept as the government, together with the main transportation stakeholders, developed the policy for MaaS. Both private and public parties closely cooperate to develop and implement the above-mentioned concept (Audouin & Finger, 2018).

MaaS Global, a finish company, started to develop the concept of Mobility as a Service and implement it in the mid-sized city of Helsinki. The name of the platform is “whim” and it offers different options to the inhabitants of Helsinki for their mobile lives. "Whim" offers plans that integrate different types of mobility services, such as public transportation, bike sharing, taxi and car rental. Since the purpose is to focus more on governance than on business, no extended analysis to the prices of the options offered by Whim will be under evaluation – they depend on the time of usage per ride, area of the city and age. Therefore, the evaluation will be based on the type of transport and their integration (TaaS) (Figure 5).

Whim Urban 30	Whim Weekend	Whim Unlimited	Whim to Go
Unlimited Public Transport	Unlimited Public Transport	Unlimited Public Transport	Pay as the user goes
Bike-sharing	Unlimited Bike-sharing	Unlimited Bike-sharing	
Limited Taxi	Limited Taxi	Unlimited Taxi	
	Car-sharing	Car-sharing	

Figure 5 - Whim Packages (source: <https://whimapp.com/plans/>)

Furthermore, the concept is currently being explored in Portugal as well, in Cascais. Through MobiCascais, Cascais is giving the first steps to integrate mobility with combining train, buses, and bike and car sharing. Additionally, MobiCascais just introduced the option for online payment for the single travels and monthly packages the platform offers. It is still in a primary stage, however the first steps have been given and Cascais is a pioneer of Mobility as a Service in Portugal.

2.5. Summary

Analysing the 2030 Agenda for Sustainable Development of the United Nations, consequently, there was the need to analyse the 2011 White Paper of the European Commission. The 2030 Agenda paves the path for the creation of a fair future for the next generations to come and Europe is indeed very much committed to achieving that. Sustainable Development is a holistic concept that acknowledges different themes, and transportation plays a role in achieving it.

The Sustainable Urban Mobility Plans guidelines are tools that can support countries defining their own plans for transportation and the mobility of the population and trades, decreasing the harm to the environment. At the end of the chapter various examples of measures for Sustainable Urban Mobility were explained and some examples of real application.

Firstly, it was tackled urban planning and its role in sustainable mobility. In order to make mobility easier, the distances for achieving work, education and services should be as shortened as possible and infrastructure must be provided for movement. Urban sprawl is a reality and it is growing due to the socio-economic background of people, because living in centres is becoming constantly less affordable. The example of Great Manchester was presented, due to the need to include measures in order to prevent urban sprawling in local policies, making cities more inclusive and attractive. Then, congestion charging is a methodology already used in various cities, especially the variety of parking pricing. Road pricing is more reserved for cities which face severe congestion problems. However, the measure for parking pricing present in the city of London is already being implemented in a lot of cities, it should be accompanied by a thorough screen off in order to make it efficient. Besides, the introduction of active mobility in cities is one great measure to be taken. It is imperative to start by providing the right infrastructure to make it possible, due to the safety and attractiveness of the modal shift. Walking and cycling are ways of moving which cause no damage to the environment and they are very good for the population's health and well-being. Different cities already are paving into the direction of making active mobility accessible. Shared mobility is as well a measure to be considered, because it contributes both to decreasing congestion and GHG emissions. Though it still has a footprint, it can be added as one of the modes in an integrated approach. In order not to exclude the motorised vehicles, alternative energy sources are measures to be explored. In the century we live in, and with the need to do different movements than the rest of the population both for work and leisure, it is important not to completely exclude the private car of the agenda, but indeed to make other types of transportation more attractive and to decrease the damage caused by fuel. Therefore, for all motorised vehicles, electric and hybrid cars are in the agenda in order to make them less harmful. Finally, in order to combine the above-mentioned measures, Mobility as a Service is an approach to integrated, personalised and accessible mobility that had its most successful development in Helsinki and, besides being initiated in different cities, Cascais is as well introducing the methodology.

The reflection on these different measures is crucial for the present research, since it provides a state-of-art of the path the World and Europe want to pave, as well as some examples of how to do it. Chapter 3 will be an analysis of the city of Aveiro and the population's

behaviours and so the beginning of a reflection on the adaptability of the above-mentioned measures for the mid-sized city

Chapter 3

The Population of Aveiro City

3. The Population of Aveiro City

In the previous chapter, the analysis of the existing policies and guidelines were analysed. With that, some measures for making Sustainable Urban Mobility a reality were acknowledged. This previous exercise aimed at creating a global mindset of the path to pursue for achieving sustainable development. Chapter 3 aims at giving context of the what defines the population and movement of Aveiro, in order for afterwards to pursue to an accurate analysis of the adaptability of the mobility plans of the city, both to its context as for the required at the global and European levels.

The city of Aveiro was selected because of its challenging characteristics – it is a mid-sized city, with high levels of urban sprawling and with the lack of mobility services, such as an efficient local public transportation and infrastructure for active mobility. Aveiro (Figure 6) is a Portuguese city, situated in the Centre Region of Portugal, in Region of Aveiro and it belongs to the district of Aveiro. It has an area of 197.58 square kilometres.



Figure 6 - Placement of Aveiro in the Portuguese territory

Going through chapter 2, it is clear that people play the most important role in urban planning – their habits, their needs, their development and it goes on. Therefore, for an understanding of Aveiro and the town's mobility needs, the diagnosis of the population density, background and behaviours is crucial. Chapter 3 is aligned with the diagnosis pursued the Mobility Plan of Aveiro Municipality. The analysis is population-based because the present research excluded freight transportation.

In order to provide a clear understanding of the characteristics of the number of inhabitants of Aveiro and how they are placed in the territory, firstly it is pursued an analysis of the evolution of the number of inhabitants of Aveiro and a comparison of the number of inhabitants between the municipalities of the Region of Aveiro. Finally, the population

density of Aveiro was compared to the population density of Portugal, Centre Region and Aveiro Region.

There is as well the need for understanding the socioeconomic background of the population because it plays an important role in their commuting needs and budget. Therefore, the ageing of the population, daily activity (employed, unemployed and studying) and the business volume present in the city are analysed.

Finally, for an analysis of urban mobility, commuting habits of the population play a vital role. Hence the analysis of the number of movements generated by Aveiro, generated by other cities to Aveiro, their destiny (if intra-municipality or inter-municipalities) and the average time of those movements. Besides, there is a need to clearly understand the transportation modes mostly used and the movements done per transportation mode. Fuel consumption plays, indeed, a vital role in this, because of the harm it causes to the environment and it is the main reason transportation acts for climate change. For that reason, a brief analysis of the motorisation rate and fuel consumption in the city was done.

In chapter 3, both data from 2011 Census (Statistics Portugal, 2012) and 2001 Census (Statistics Portugal, 2002) are considered. Only when there is no available data of the 2011 Census (Statistics Portugal, 2012), 2001 Census (Statistics Portugal, 2002) was chosen.

3.1. Population Density

In Figure 7, it is possible to observe the evolution stated in the last Census from 1991, 2001 and 2011, developed by Statistics Portugal, where the population increased during that time, regardless of the changes in the pace's growth. The population growth rate from 1991 to 2001 was 10.4 per cent and from 2001 to 2011 was 7.0 per cent. While from 2010 to 2017 (77 630 inhabitants to the statistics provided by Statistics Portugal) was -1.0 per cent, where Aveiro suffered small depopulation.

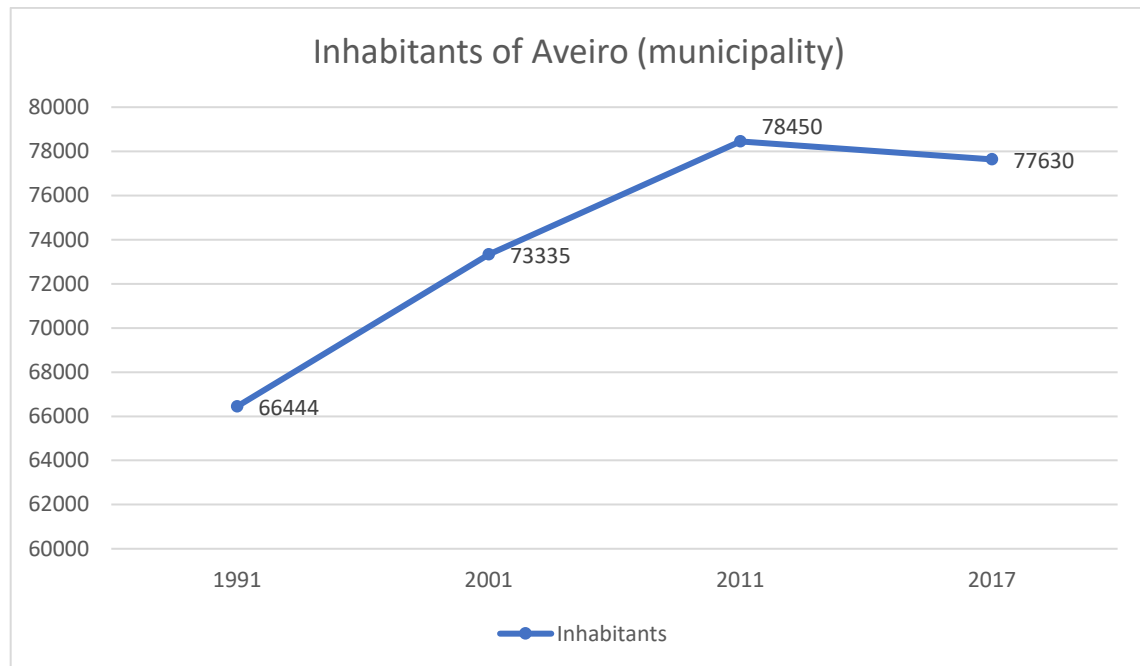


Figure 7 - Number of Inhabitants of Aveiro collected by Census for the years of 1991, 2001 and 2011, a value estimated for the year of 2017 (Source: Statistics Portugal)

Comparing to the different municipalities of the region, in the 2011 Census, Aveiro is the municipality with the highest number of inhabitants. The municipality with the second-highest number is Ovar, with 55340 inhabitants. In Figure 8, it is presented the comparison between the municipalities (Statistics Portugal, 2012).

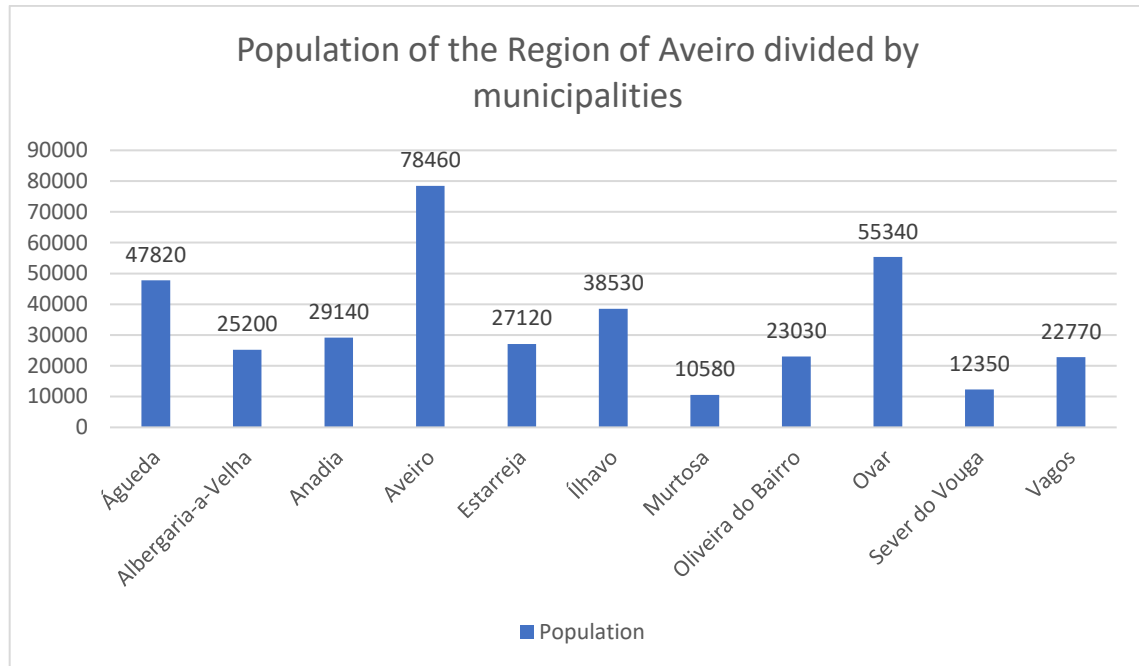


Figure 8 - Number of inhabitants in the different municipalities of the region of Aveiro (Source: 2011 Census) (Statistics Portugal, 2012)

Consequently, the population density suffered some small changes. Despite that decrease of the number of inhabitants in the city, Aveiro is still the municipality with a population density higher than the continent, the centre region and Aveiro region. According to Statistics Portugal, Aveiro has a population density of 392.9 *Inhab./Km²* inhabitants per square kilometre (Statistics Portugal, 2012). The comparison of the values can be found in figure 9.

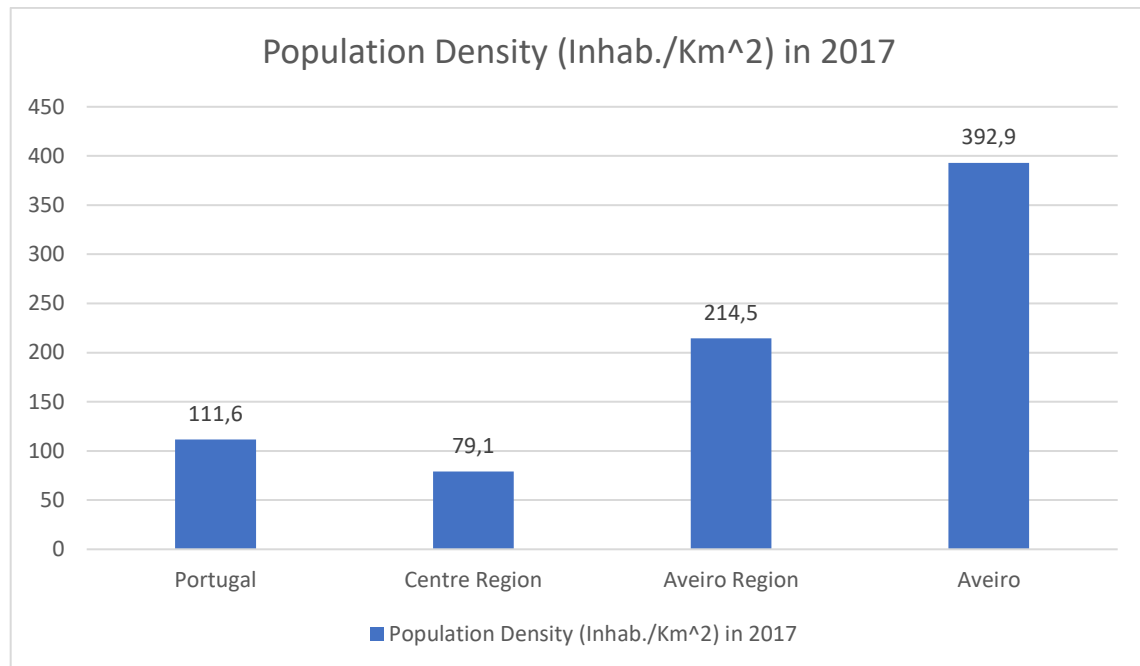


Figure 9 - Population Density of the continental Portugal, Centre Region, Aveiro Region and Aveiro in 2017 (source: www.ine.pt)

3.2. Socioeconomic Background

In this part, an analysis of the socioeconomic background of the population of Aveiro will be pursued, since it was one of the main factors that determine where people live and how they commute.

3.2.1. Population Ageing

Regarding the ageing of the population, in table 7, it is possible to observe the number of elderlies having a quicker increase than the other age groups. In the year 2017, the ageing index was 138.9 per cent as, comparing with the last Census (2011), it was 116.1 per cent (Statistics Portugal, 2012).

Table 7 - Number of inhabitants of Aveiro per age group (source: 2011 Census) (Statistics Portugal, 2012)

Age Group	Inhabitants				
	2013	2014	2015	2016	2017
	Nr.	Nr.	Nr.	Nr.	Nr.
Total	77 229	76 935	76 882	77 241	77 630
0 – 14 years	11 219	11 048	10 833	10 856	10 902
15 – 24 years	7 962	7 955	8 090	8 054	8 056
25 – 64 years	44 231	43 769	43 473	43 534	43 527
65 - forward	13 817	14 164	14 486	14 767	15 145

By the analysis of the values of table 7, the dependency ratio is 50.5 per cent by 2017, while in 2011 it was 45.4 per cent (Statistics Portugal, 2012). Together with the evaluation of the other years, this means that the population of Aveiro has been becoming more dependent.

3.2.2. Unemployment, Employment and Students

By 2011, the unemployed population in Portugal was 662180, while in the Centre Region was 116014 (17.5 per cent of the unemployed population in the country) and in the Region of Aveiro 20416 (3.1 per cent of the unemployed population in the country and 17.6 per cent of the unemployed population in the Centre). In Figure 10, it is presented the distribution of the unemployed population in the Region of Aveiro by its municipalities. Aveiro has 4302 unemployed, which is 21.1 per cent of the region's unemployed population and it represents 8.3 per cent of the active population of the municipality (Statistics Portugal, 2012).

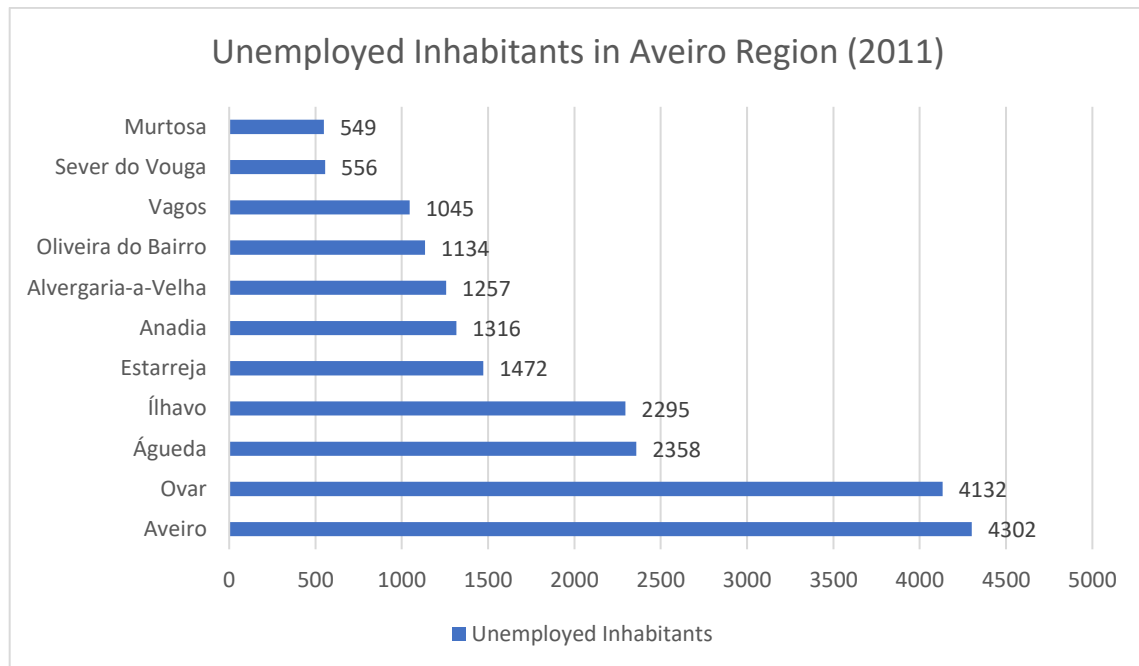


Figure 10 - Unemployed Inhabitants of the Region of Aveiro, divided by municipalities (Source: 2011 Census) (Statistics Portugal, 2012)

By 2011, 35791 inhabitants of Aveiro were employed. The division of the employees by sector can be found in Figure 11 (Statistics Portugal, 2012).

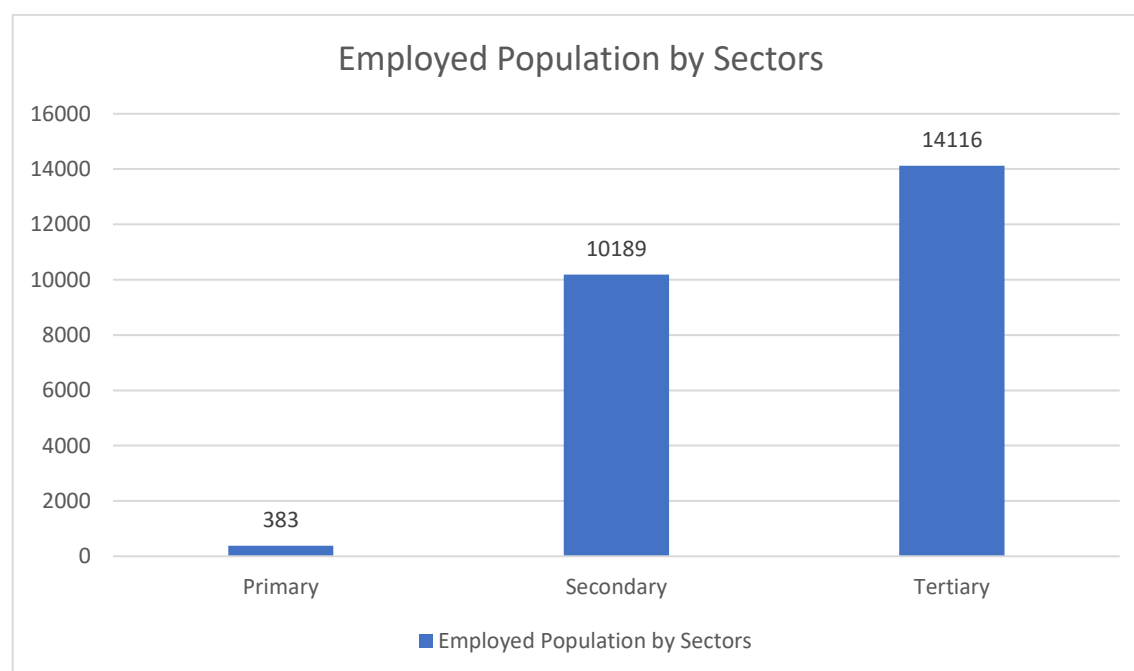


Figure 11 - Employed population in Aveiro divided by primary, secondary and tertiary sectors in 2011
(source: 2011 Census) (Statistics Portugal, 2012)

Additionally, by 2011, there were 12874 students in Higher Education (University of Aveiro) and there were 15621 students at other levels and types of education (Statistics Portugal, 2012).

3.2.3. Companies and Business Volume

In Figure 12, it is represented the number of companies with their headquarters in the region, divided by municipalities, and Aveiro shows the highest number of companies within the region. The municipality represents 23.7 per cent of the region's companies. Additionally, the 8809 companies based in Aveiro have the business volume of 2 472 791.67, which represents 20 per cent of the business volume of the Region of Aveiro.

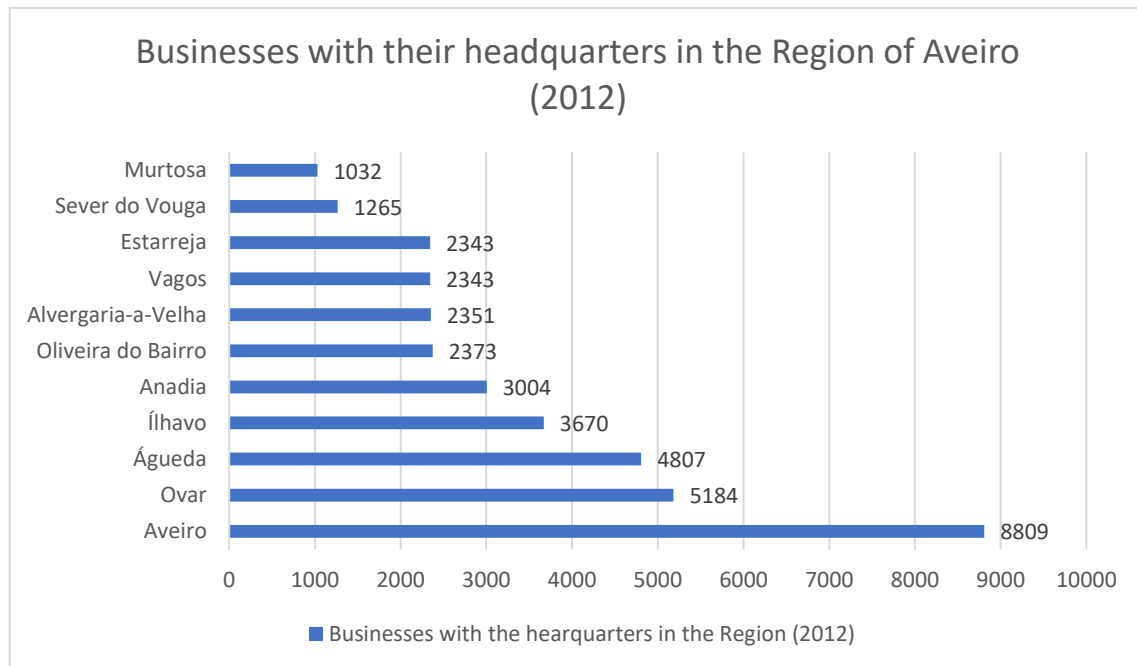


Figure 12 - Number of businesses with their headquarters in the Region of Aveiro, divided by the regions' municipalities (Source: Câmara de Comércio e Indústria do Centro)

3.3. Commuting

The active inhabitants of Aveiro work/study inside or outside the municipality, which is translated into different movements between the inhabitants. 9560 inhabitants leave the municipality to pursue their daily activities. Moreover, the population living in other municipalities work or study in Aveiro are 27923 people. Commuting of the populations of the Centre Region makes Aveiro interacts with 17 municipalities of the Region (Statistics Portugal, 2002).

In table 8, it is possible to find the number of people commuting generated by the municipality to other municipalities and from other municipalities to Aveiro (Statistics Portugal, 2002).

Table 8 - – Number of people commuting divided by the origin region (Source: 2001 Census) (Statistics Portugal, 2002)

Generated in Aveiro			From another municipality to Aveiro		
Region of Aveiro	Other destinations	Total	Region of Aveiro	Other origins	Total
3 8231	1 802	5 633	13 979	6 469	20 448

In table 9, it is possible to find the number of people that move inside Aveiro, that enter Aveiro and leave for their daily activities (Statistics Portugal, 2002).

Table 9 - Number of people commuting inside the municipality, from Aveiro to another municipality and from other municipality to Aveiro (Source: Census 2001) (Statistics Portugal, 2002)

	Generated in Aveiro			From another municipality to Aveiro
	Inter-Municipalities	Intra-Municipality	Total	
Active Population	5 094	29 672	34 766	16 931
Student Population	539	10 737	11 276	3 517
Total	5 633	40 409	46 042	20 448

In table 10, it is presented the average time for commuting of the inhabitants. The average time is 15.95 minutes. Although for the residents travelling on individual vehicles the value is shortly below average, for residents travelling in collective transportation the value much higher than the average (Statistics Portugal, 2012).

Table 10 - Average time in minutes of commuting by inhabitants that study or work (source: 2011 Census)

Average time for the community by students and employed inhabitants (min)		
All the vehicles	Individual vehicle	Collective vehicle
15,95	14,93	30,55

3.3.1. Transportation Mode

In Figure 14, it is possible to find the percentage of transport modes for commuting inhabitants of Aveiro, the Region of Aveiro and the Centre Region use, by 2001. The three of them present a high percentage of private car usage. About the percentage of private usage, Aveiro presents a higher value (55%) than the value of the Region of Aveiro (52%) and the Centre (52%). Additionally, the percentage of walking in Aveiro (20%) is the same as that of the entire region of Aveiro (20%) and this value is lower than the one from the Centre (24%). The share of public transport for the city of Aveiro is 14 per cent, for the Region of Aveiro 14 per cent as well and for the Centre Region 17 per cent. The share of motorcycles and bicycles is 8 per cent in the city of Aveiro, in the Region of Aveiro is 12 per cent and in the Centre Region 5 per cent, which presents positive values compared to the Centre Region.

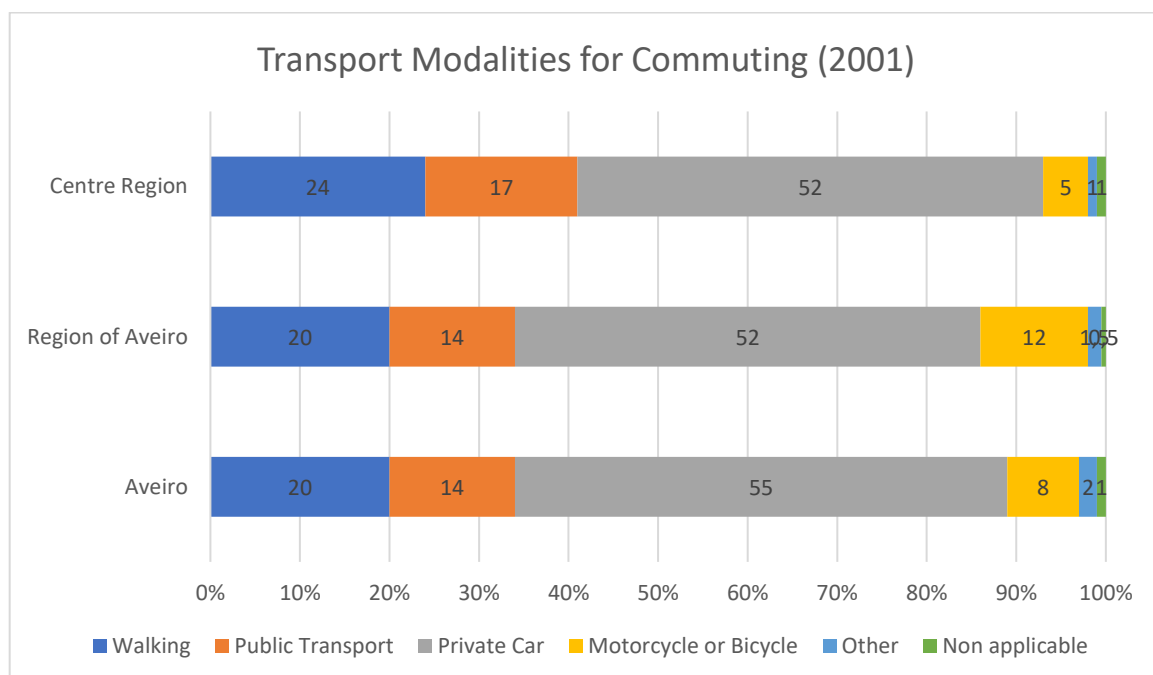


Figure 13 - Division of the transport modalities for commuting of the inhabitants of Aveiro, Region of Aveiro and Centre Region (source: 2001)(CIRA, 2012)

There are 24077 inhabitants that use the car as the driver and only 9118 inhabitants that use the car as a passenger. Then, 5775 people walk to pursue their activities and 3367 inhabitants

take the bus. In Figure 13, the division by way of transportation is presented (Statistics Portugal, 2012).

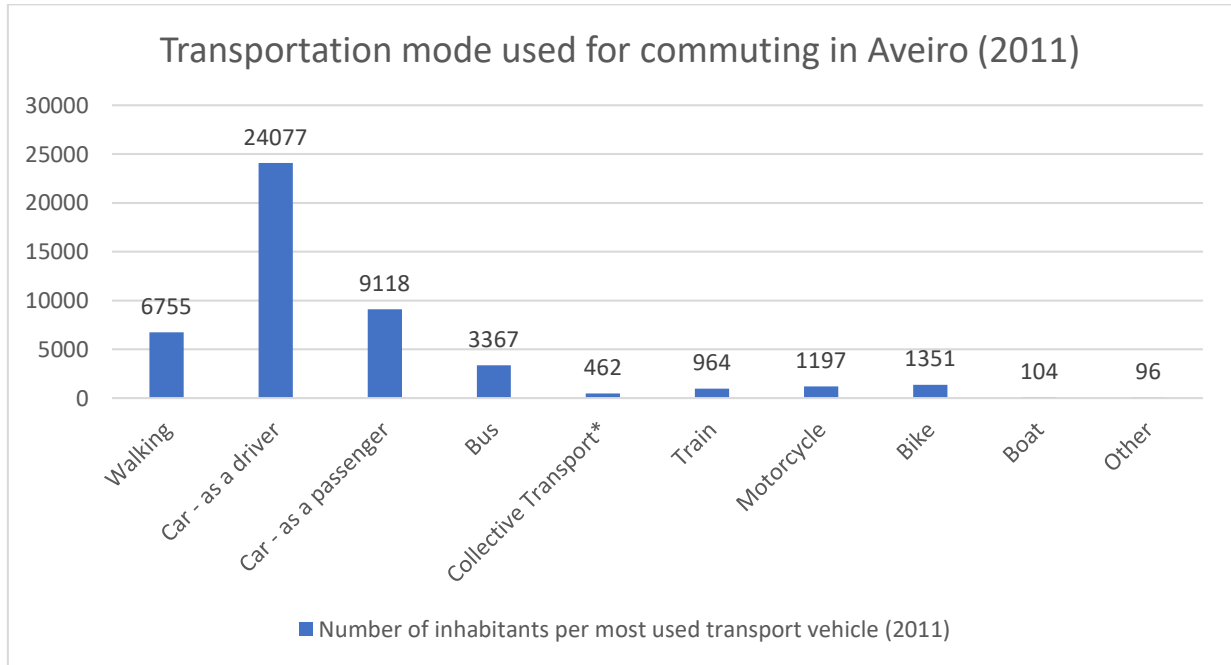


Figure 14 – Transportation mode used for commuting in Aveiro (source: 2011 Census) (Statistics Portugal, 2012)

Regarding the movements within the municipality by the inhabitants of the city, in Aveiro by 2001, the private vehicle is still predominant. The share of private car usage is 53 per cent, while the share of walking is 23 per cent, public transport is 13 per cent and motorcycle and bicycle is 10 per cent. Regarding the movements between municipalities, the private vehicle is again predominant with a share of 70 per cent. Additionally, the share of walking is 1 per cent, which is justified by the distance to walk between municipalities, the share of public transport is 23 per cent and the share of motorcycle and bicycle is 5 per cent (CIRA, 2012). In table 11, it is presented the number of commuting movements, divided by the origin and destiny and per transportation vehicle (Statistics Portugal, 2012).

Table 11 - Number of commuting movements per transportation vehicle, divided by origin and destiny
(source: 2001 Census) (Statistics Portugal, 2002)

	Generated in Aveiro			From another municipality to Aveiro
	Inter-Municipalities	Intra-Municipality	Total	
Car	4 228	21 422	25 650	14 109
Motorcycle/ Bicycle	299	4 007	4 306	912
Train	521	202	723	1 920
Collective Transportation	246	4 579	4 825	1 732
Walking	42	9 278	9 320	320
Others	297	921	1 218	1 455

3.3.2. Motorisation rate and fuel consumption

In 2010, the motorisation rate of the region was 502 vehicles per 1000 active inhabitants. From 2003 to 2010, the rate increased to 42 per cent. Aveiro had an increase of 35 per cent, however, it was not the highest increase in the region (Sever do Vouga had an increase of 60 per cent and Vagos of 56 per cent). Alongside with the increase of the motorisation rate, parking grew about 43 per cent, which represents a high value, since the value of the continent was 26 per cent. In 2010, there were 185500 parking spots in the region (CIRA, 2012).

The fuel consumption, in the region, from 1999 to 2010 increased by about 34 per cent. Some municipalities decreased their consumption: Anadia (-24%), Estarreja (-32%), Murtosa (-30%), Oliveira do Bairro (-18%) and Sever do Vouga (-42%), but Aveiro faced a tremendous increase: the consumption grew around 126% (Source: Direção-Geral de Energia e Geologia) (CIRA, 2012)

3.4. Summary

In the present chapter, a brief analysis of the population of Aveiro and of their mobility behaviours was presented. It is possible to observe that the main data results used were from the years 2001 and 2011. Those were the results used utilised for the definition of the mobility plans for the municipality and including the municipality. Since the year 2001, Aveiro suffered a lot of changes within the population and, especially, within its mobility needs. For example, tourism had a strong increase and it is not taken into consideration in the mobility plans and in the present work. Additionally, the data used in the present dissertation was from the last two census due to the data treatment of 2011 Census, meaning that the values are from different years, aiming to create the most realistic scenario.

Aveiro presents the highest population of the region of Aveiro and a population density higher than the average. From the active population, only 9560 leave the municipality to pursue their daily activities and Aveiro receives 27 923 residents of another municipality for the same purpose. For its daily activity, Aveiro counts with a high number of individuals, residents or not, making efficient commuting a challenge. Additionally, it presents a dependency ration of 50 per cent, which represent how the active population is pressured economically. The ration has been increasing for the past years. The number of inhabitants and, especially, the dependency ration require an efficient service provider in Aveiro.

Concerning the activity of the city, the number of employees working in the municipality is 35791, mainly ant tertiary sector (services). Besides, the University of Aveiro counts with 12874 students pursuing their studies in the infrastructures based on the municipality and, besides Higher Education, Aveiro has 15621 students. A considerable number of companies are based in Aveiro (23,7% of the region) and the city has 20 per cent of the region business volume. Inhabitants of the city face unemployment, 4302 inhabitants, which represents 21.1 per cent of the region. For an effective activity, a city must present an efficient mobility infrastructure for the people pursuing their daily activities. Additionally, due to the high need for movement, greenhouse gas emissions tend to increase since people use mostly motor vehicles (as it was presented before).

When utilising collective transportation, inhabitants tend to spend double of the average time to reach their destinies. However, when using individual vehicles, inhabitants spend a bit less time than the average to reach their destinies. These two statements can be affected by the distance needed to be pursued and by the services offered by the municipality and the region. The number of users, both inhabitants and employees, of collective transportation is low (13%) when compared to individual transportation (53%). However, the share of people walking is satisfying (23%). In order to define a strategy, it is crucial to understand why this happens in the city of Aveiro. Does Aveiro offer the needed infrastructure for sustainable mobility? Are the mobility plans of the municipality contributing to the 2030 Agenda for Sustainable Development of the United Nations? These are questions which will be further explored in chapter 4, where the existing local plans will be thoroughly analysed.

Chapter 4

*The Sustainable Development Goals
and the Sustainable Urban Mobility
Plan of Aveiro*

4. The Sustainable Development Goals and the Sustainable Urban Mobility Plan of Aveiro

In this chapter, the SDGs which were identified as directly influenced by transport in chapter 2 will be analysed and, consequently, their targets. The understanding of the impact of the actions of mobility plans in the 2030 Agenda of the United Nations is crucial for a better comprehension of the path cities are following for Sustainable Development. This will foster the analysis of complementary actions. Hence, this chapter will include a recommendation for a measure to empower the already existing actions.

The analysed plan is the Sustainable Urban Mobility Plan of Aveiro (PMUSA). PMUSA proposes actions for long, medium and short terms to achieve sustainable mobility within the urban area of Aveiro. The proposed actions are co-financed by the European Regional Development Fund (ERDF), a tool created by the European Union in order to support regions in strengthening their weaknesses. This plan is one of the three action plans of the Strategic Plan for the Urban Development of the Municipality of Aveiro (*Plano Estratégico de Desenvolvimento Urbano do Conselho de Aveiro* – PEDUCA). PMUSA focuses on Urban Mobility. PEDUCA counts with 9 900 000 euros from ERDF, and from this amount, PMUSA is co-funded with 1 013 625 euros by ERDF.

For an accurate understanding of PMUSA, of the proposed actions and how to implement them, there are two plans which complement it: Mobility Plan of Aveiro Municipality (PMMA) (Município de Aveiro, 2012) and the Inter-Regional Mobility Plan of the Region of Aveiro (PIMT-RA) (CIRA, 2012).

PMMA is a plan that focuses on all aspects of mobility in the municipality and PIMT-RA is a plan that focuses on the mobility of the region of Aveiro. PMMA is in his conclusion state while PIMT-RA was already concluded. Both plans give a basis for the creation of PMUSA, since they provide cities with a perspective of all types of mobility with the influence of the exterior, not only focused on the municipality. As well the actions proposed by PMUSA are integrated into the actions taken due to PMMA and PIMT-RA.

4.1. The actions of PMUSA

PMUSA is a plan, as previously stated, sustained in two other previously developed plans: PMMA and PIMT-RA; and it is the action plan for the mobility component of PEDUCA. The defined actions were partially funded by the ERDF – 2 071 875 euros. The total investment is 2 437 500 euros. The implementation length is from 2016 to 2020 (Município de Aveiro, 2015).

The proposed actions can be divided into two main fields: “Active Mobility and Interfaces’ Network”; “ICT to support the management of the network and citizens”. The actions of “Active Mobility and Interfaces” are highly dependent on urban planning. There is a strong emphasis in the construction or rehabilitation of roads for bikes or pedestrians and as well of public transport and services, such as BUGA, the bike sharing service from Aveiro.

Additionally, there are action focused on the education of the population. This field recognises the need for having integrated ticketing. Finally, one of the actions of this field is focused on the development of mobility plans for areas generating traffic. Regarding “ICT to support the management of the network and citizens”, two actions were defined. One of them is the creation of a live Information System of an integrated mobility network. The other action is focused on traffic management, as the integration of information systems in order to monitor and control road traffic (Município de Aveiro, 2015).

Additionally, there are two types of indicators for PMUSA, which are indicators of realisation and result. The indicators of realisation are: SUMPs implemented; roads dedicated to active mobility or decrease of CO₂ emissions; mobility projects approved; roads of high transportation demand implemented; multimodal interfaces implemented. Regarding the indicator of result: decrease of 8 per cent of the greenhouse gas emissions by 2023 – the value in 2008 of greenhouse gas emissions generated by transport in Aveiro was 84756 ton CO₂ (Município de Aveiro, 2015).

Following on that, the analysis of the actions constituting PMUSA will be analysed, in order to understand the reality of Aveiro and then pursue, to pursue afterwards an understanding of how aligned PMUSA is with the Sustainable Development Goals.

4.1.1. Active Mobility and Interfaces

Bellow, it is possible to find the different actions taken for the field “Active mobility and Interfaces”. They focus on active mobility, on an integrated approach to different modes of transport, the management of the transportation network, management of the high demand routes and, finally, the development and implementation of mobility plans.

4.1.1.1. Development of Active Mobility

Through this measure, the aim is to decrease carbon emissions. This measure contains different actions to achieve its goal.

The action A1.1.1 proposes the construction of dedicated roads for people walking and riding a bicycle. The Action A1.1.2 proposes the comprehension of the already existing roads that can have bicycle moving alongside motor vehicles and so the needed interventions on the crossings, in order to make the bicycle usage safe for all. In Appendix 1, the map with the differentiated roads from the City Hall is available. A1.1.1 is dedicated to roads of the 1st level and A1.1.2 is dedicated to roads of the 2nd level. These two actions aim to create and implement routes ensuring the connection between surroundings and between municipalities.

The action A1.1.3 aims to intervene in the problematic areas in 2nd level roads, complementing the action A1.1.2. This action acknowledges the crossings presenting problems regarding intermodal mobility. It will reformulate road practices to increase the safety of pedestrians, bicycle users and car users.

The actions of A1.1.4 and A1.1.5 aim to create awareness among the population for active mobility and its perks. A1.1.4 interventions are based on the Campus of the University of Aveiro, focusing the actions in the community working in the University of Aveiro, and A1.1.5 interventions are based in the municipality, focusing the actions among primary schools, teachers and parents.

4.1.1.2. Strengthen the integration of intermodal transportation

This measure aims to improve the quality of intermodal mobility. The action under this measure is A1.2.1, that aims to implement a ticket management system promoting intermodal transportation between transportation modes.

4.1.1.3.Improvement of Interface's Network

The improvement of interfaces and how they work together is crucial to implement an efficient Plan for Sustainable Mobility. Firstly, A1.3.1 aims to review how the management of transportation systems (Centro Coordenador de Transportes – CCT) operate, in order to increase their accessibility and efficiency. Additionally, A1.3.2 focuses on active mobility – the requalification of BUGA, as a bike-sharing system implemented on the inhabitants daily-lives, as one component of intermodal mobility of Aveiro. Finally, A1.3.3. aims to intervene in interfaces of public transportation, with more attention to parking lots in the surroundings as support to intermodality.

4.1.1.4.Structure routes of high demand

The action under this measure is A1.4.1. It aims to intervene to ensure the total functioning of the public transportation network and active mobility vehicles. The interventions are on the roads ensuring the connections between the surroundings and between municipalities. A1.4.1 aims to decrease the presence of cars in the city centre.

4.1.1.5.Mobility Plans

The action under this measure is A1.5.1. It aims to develop a mobility plan for the traffic hotspots of the municipality, by changing the mobility habits of the population, create awareness about sustainable mobility and to promote intermodal mobility. Additionally, it aims to increase road safety.

4.1.2. Information and Communication Technologies

In this part, it is possible to find the actions the two measures of this field are translated into. Firstly, the information systems in real-time and then the implementation of smart services and innovative solutions to manage high demand routes.

4.1.2.1.Information Systems in real-time

The action under this measure is A2.1.1. It aims to create a system where users and services would have a better perception and real-time perception of the connections between public transportation. The goals would be to promote intermodality, prioritizing active mobility vehicles networks and public transportation.

4.1.2.2.Implementation of smart systems and innovative solutions

The action under this measure is A2.2.1. This action aims to implement smart traffic control, in order to improve the management and security of transportation. The subsystems to be implemented would be lighters activated by velocity controls and panels with variable messages, for example.

4.2. Sustainable Development Goals

This part is dedicated to the Sustainable Development Goals that are directly influenced by transport, as mentioned in chapter 2. Hereafter, the indicators under these SDGs where transportation has a role in it will be identified as a small reflection of the connection between the targets, transportation and Aveiro.

4.2.1. Sustainable Development Goal 3

The connection between SDG 3 and transport happens more precisely in the target 3.6: “*By 2020, halve the number of global deaths and injuries from road traffic accidents*”. By analysing accidents, the identified descriptors are: transport; local development structure; infrastructure facilities (besides those for transport); population structure (Ulrike Henning-Hager, 1986).

The structure of the population of Aveiro (as previously stated) presents a dependency rate of over 50 per cent, meaning that the population is very much dependent when it comes to responsible movement. Additionally, the number of the dependent population, especially the elderly, is very high. This part of the population may not have the needed road education for safe behaviour.

4.2.2. Sustainable Development Goal 7

The connection between SDG 7 and transport bases itself in the target 7.3: “*By 2030, double the global rate of improvement in energy efficiency*”. In order to achieve it, there is a need to define a framework for low emission alternative energy, create infrastructure for alternative fuels and foster interoperability and standardisation for electro-mobility (European Commission, 2016).

Additionally, not only for energy efficiency but transport efficiency, intermodal planning is required and so infrastructures and technologies to support it. Aveiro presents high activity, compiling with different businesses and companies, a university and the rest of basic services for the population. This can be translated into a high movement of goods and people, that spend a lot of energy generating greenhouse gas emissions. In Europe, road transport is the biggest emitter of GHG in the field of transport.

4.2.3. Sustainable Development Goal 9

The connection between SDG 9 and transport relies on the target 9.1: *“Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all”*. For this target, intermodal planning and moving for healthy vehicles should be the focus.

Aveiro presents a small share of the population that use collective transportation since it does not answer to their needs. To use collective transportation takes twice the time a private vehicle takes to arrive at a destiny. Besides, in Aveiro, the intermodal mobility systems are not a reality. The collective transportation between parishes is very low and not reliable. The service for renting bikes exists (BUGA), but it doesn't offer the needed infrastructures. Additionally, there are no dedicated roads for bikes covering the entire city and connecting services.

4.2.4. Sustainable Development Goal 11

The connection between SDG 11 and transport relies on target 11.2, which is *“By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons”*. This target is very connected with the previously analysed targets.

Sustainable mobility, in all its levels, is indeed very relied on public transportation. The existence of easy access, affordable, accessible, intermodal transport systems is crucial for the construction of smart cities. Additionally, how available the information about the systems is crucial for good functioning and to achieve a productive intermodal system. Aveiro has a network of public transportation, which covers part of the city, and it is introducing now hybrid buses.

4.2.5. Sustainable Development Goal 12

The connection between SDG 12 and transport relies on target 12.C, which is the following *“Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities”*. This target is clearly connected with national policies however cities can play a role in achieving it.

In order to decrease the dependency on fossil-fuel, governments must take action into the regulation of how fossil-fuel is utilised. The target 12.C is not directly connected to the local level, nevertheless cities can have an important role in it, by influencing their local policies favouring active mobility or the usage of alternative sources, as stated in chapter 2.

4.3. SDGs’ Targets and PMUSA

In order to achieve Sustainable Mobility, the most needed change is in the population behaviour. PMUSA was defined according to European directives for Sustainable Urban Mobility Plans. The aim of PMUSA is to decrease the traffic volume in the city centre, create

a friendly area for both bicycles, pedestrians and motor vehicles coexist and consequently decrease the carbon emissions of the city.

The creation of hierarchies for different mobilities in the road is extremely important for safety and efficiency. The 1st level implements side routes for bicycles and pedestrians alongside the roads for cars, giving the chance for the inhabitant to choose between modalities with the same efficiency. The 2nd level combines both motor vehicles and bicycles in the same road, however with a 30km/h limit for the motor vehicles. This way, both motor and active mobility vehicles can coexist offering no danger. A route connecting the train station and the University of Aveiro is already in the project phase and soon the contest for its implementation will be launched.

The intervention in problematic areas is dedicated to one of the biggest problematics when joining bicycles and motor vehicles in the same routes: crossings. Crossings are extremely problematic when it comes to safety and efficiency. That is why PMUSA identified the areas which needed intervention to achieve the aim of a friendly and safe for all vehicles. One of the interventions is the new roundabout near the University Campus.

Both actions for creating awareness depend on other bodies than the municipality. These tackle one of the biggest key-changers of Sustainable Urban Mobility – the education of the population. The University of Aveiro started to implement U-Bike project to achieve it, but the company providing the bicycles bankrupted.

Previously, the City Council of Aveiro granted the public transportation of the municipality to the private sector. Due to this decision, it became very difficult to achieve the integrated ticket system planned in PMUSA, once it does not depend on the municipality itself but on the private sector. This decision affects the creation of an Information Technology System with an intermodal approach since it depends on Transdev. However, the requalification of CTT already happened, making it possible to start developing the public transport sector in Aveiro.

The implementation of a bike-sharing system as one of the modes for commuting, playing a vital role in the intermodal approach to mobility, is an important aspect of the decrease of carbon emissions. The requalification of BUGA will be crucial for the implementation of PMUSA, but it is mandatory that the system answers to the users' needs and it is reliable – the system has to present from the beginning the needed spots to pick-up and return a bicycle as well as the sufficient number of bicycles for the users.

The interventions in the support of intermodal mobility such as the creation of parking lots are a sensitive part of the plan. PMUSA aims to eliminate the creation of traffic generators in the city centre as well to decrease the usage of motor vehicles for commuting. The creation of parking lots is highly advised to take place in the surroundings of the city and as one of the tools for integrated mobility. The requalification of the parking lot near Aveiro's Train station is one of the examples.

In Table 12, the connection between PMUSA Actions and SDGs' Targets are presented. Here it is possible to find that almost every target connects with the actions of PMUSA. The only exception is target 12.C, since, as previously stated, this action aims at being pursued by national authorities, and the local level can support its implementation and foster responsible behaviour in their cities. Nevertheless, it is important to recall the parking pricing implemented by the city of London, where the prices for parking of private cars decrease with their harm caused to the environment.

Table 12 – SDGs' Targets affected by PMUSA Actions

PMUSA Action	Sustainable Development Goals' Targets				
	Target 3.6	Target 7.3	Target 9.1	Target 11.2	Target 12.C
A1.1.1	X	X	X		
A1.1.2	X	X	X		
A1.1.3	X		X		
A1.1.4		X		X	
A1.1.5		X		X	
A1.2.1		X	X		
A1.3.1		X	X		
A1.3.2		X		X	
A1.3.3		X	X	X	
A1.4.1		X	X		
A1.5.1	X	X	X		
A2.1.1			X	X	
A2.2.1	X		X		

PMUSA acknowledges the needs exposed in the 2030 Agenda for Sustainable Development of the UN and as well the goal set by the 2011 White Paper, in decreasing the GHG emissions by 60 per cent. However, the challenge is the connectivity between these different actions and make them all work together. In the next point, Mobility as a Service is proposed as one concept to be explored in the city in order to integrate all the above measures.

4.3.1. Mobility as a Service in Aveiro

In Chapter 2, one of the measures presented for Sustainable Urban Mobility was Mobility as a Service (MaaS). This concept introduces an integrated approach both for modalities as for ticketing, while giving a real-time perspective of the routes to pursue for a certain destiny. As previously shared, different actions under this concept are in place, but the following proposal is aligned with the concept developed in Helsinki, Finland.

Hereafter, how governance of MaaS can be done will be explored and afterwards how the concept can be translated into services and actions. Finally, a reflection of the possible limitations of the system will be as well presented.

4.3.1.1. Governance of MaaS in Aveiro

Reflecting on the previous information Mobility as a Service can be an asset for the following steps of PMUSA. Therefore, here a small analysis on how MaaS could look in Aveiro is presented.

The proposed concept will be an online tool, with which the population of Aveiro can choose their journey and the connected aspects, as the various transportation systems. The considered transportation systems are the train, bus, bike-sharing, car-sharing, taxi and parking.

In order to build the proposed concept, it is crucial to understand the roles of the parties in its development. Therefore, two phases should be created for MaaS in Aveiro:

- Phase 1: Adaptation of the concept and development of the action plan;
- Phase 2: Policy Making and implementation.

For phase 1, thorough research on commuting behaviours of the region should be pursued. MaaS implementation should not be city-based and so, it is crucial to gather the existing data within the Region of Aveiro to better answer to the needs of the population. Although, the pilot project firstly will be city-based and at a later stage region-based.

Additionally, the different parties should be acknowledged, and the creation of the network should be done. The parties are: City Authorities, as Inter-municipality Community of the Region of Aveiro (CIRA), City Council of Aveiro, and Transportation and Mobility Institute (IMT); University of Aveiro; and TaaS suppliers, such as Aveiro Bus (currently operated by Transdev), Portuguese Trains Company (Comboios de Portugal – CP), Taxis and a car-sharing company. Hence, the private and public authorities will be working together from

the start. All these institutions would have to find a way on how to collaborate to make the concept a reality in the cooperation level, data sharing level and, consequently, the creation of Application Programming Interfaces (APIs).

In addition to the role of movement generator and U-bike project, the University of Aveiro should play a role in creating a supporting think-tank to the development of the system, by connecting the above-mentioned institutions.

Phase 2 would be mostly pursued by the city and regional authorities on the policy-making supporting the concept and planning developed in Phase 1. The policy should aim at finding a compromise with the other municipalities of the region, by supporting both the 2030 Agenda for Sustainable Development and the 2011 White Paper – meaning, keeping in mind the place of the population, especially the disadvantaged ones, and the environment.

In figure 15, it is possible to find the above-mentioned in a graphic.

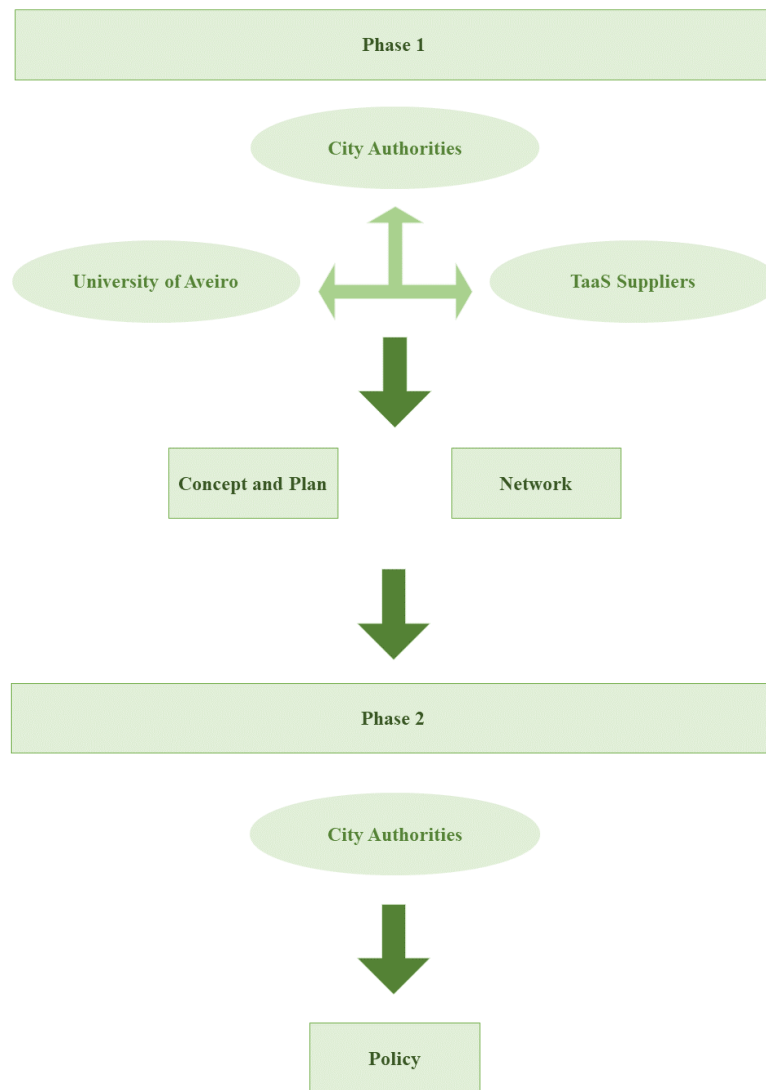


Figure 15 – Governance scheme for MaaS creation in Aveiro (source: author, based on Helsinki’s strategy)

4.3.1.2. The Services of MaaS in Aveiro

For a successful implementation of MaaS in the city of Aveiro, not only the establishment of the above-mentioned partnership, but the implementation of services, making them reliable, accessible, comfortable and cheap. One of the MaaS most important aspects is the introduction of integrated modalities, meaning, the combination of different transport systems in one single journey. To decrease the private car usage, efficient and easy to access

mobility systems must be offered as an alternative. This is what MaaS offers. In order to make integrated mobility a reality, infrastructures have to answer to the suppliers and clients' needs.

Regarding a bike-sharing system, its implementation must acknowledge the demand of the population when commuting in Aveiro, offering a proper number of bikes and a good coverage of stations to pick-up and drop-off the bikes. Car-sharing follows the same rationale. A re-evaluation to the public transportation system is required, for the system to offer the most adequate routes, in the most proper timeline, taking into account other services, such as train, and the demand.

What MaaS would offer is an integrated approach to the various modalities present in the city and the most efficient to a user's needs. The integration would be translated into an online platform, where the various routes would be presented to a user and he/she would have the freedom to choose the most adequate. Another aspect of the success of the previous integration is the payment. MaaS, as a consequence of the above-mentioned partnerships, would ideally offer the different payment options, similar to the Helsinki's example: monthly payment or on-demand.

The proposed scenario for the city of Aveiro can be practically shown by the hypothetical journey: Dulce lives in Ovar and works at the University of Aveiro.

Currently, she goes from her house to her work by car, because there is no public transportation right next to her house and she cannot park near the train station. Besides, the public transportation in the train station is not appropriate for her work schedule and it is not efficient. Summing up the costs of using public transportation as the main way of moving to work, it is cheaper to go by private car.

With MaaS application (figure 16), Dulce would have her route from home to work all combined in her phone and paid monthly. One of the routes could be: going by car to the train station and park there, without additional payment.

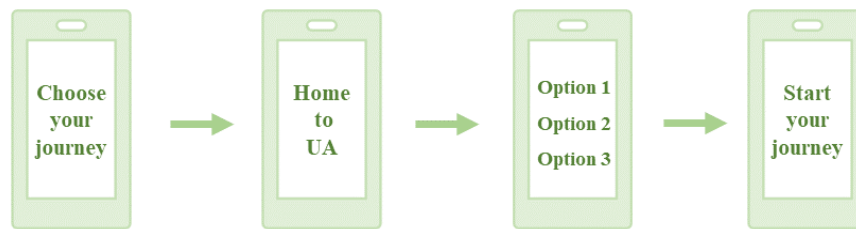


Figure 16 – MaaS' Application (source: author)

Then, she would go by train to Aveiro and when arriving in Aveiro, she would have a bike for her trip from the train station to the university that she could drop off, where she could leave in one of the stations at the university (figure 17).



Figure 17 - Dulce's journey with MaaS application usage

4.3.1.3. Challenges of MaaS in Aveiro

After the reflection of how MaaS could be implemented in Aveiro, and taking already into consideration the actions of PMUSA, it is important to analyse the possible challenges of the process, both regarding governance and services.

Concerning governance, one of the most likely limitations of the implementation of the process would be the creation of partnerships. Therefore, to align the different parties, public and private, in order to create a unified service, can be a great challenge, but MaaS relies on the partnerships created.

Regarding the services, one challenge that MaaS will face is the understanding of the demand of the different services offered, once implemented. Therefore, the pilot phase should be

very much focused in understanding the trends of the users (Sochor, Karlsson, & Stromberg, 2015).

After this proposal and all the considerations, the next chapter presents the final reflections on the research developed and as well the work it should be continued in future research.

Chapter 5

Final Remarks

5. Final Remarks and Future Developments

Reflecting on the previous chapters and the path pursued in this dissertation, this chapter aims at providing remarks of the research pursued and a reflection of the future works to take in place for further research.

5.1. Final Remarks

Sustainable Development Goals do not work individually for each one's fields, they are integrated in the 2030 Agenda and, besides complementing each other, they as well are dependent of the entire framework. PMUSA acknowledges the city's potential in order to be an incubator of sustainable behaviours, as it is possible to observe in the crossing of the actions proposed in the plan with the Sustainable Development Goals 3, 7, 9 and 11. It is crucial to highlight, even though it was not presented as directly connected, that SDGs 13 and 17 play an important part. Firstly, climate change is the main reason why countries need to reassess their mobility plans, as previously stated, and it is indeed the main reason why this dissertation was pursued in the first place. The analysis of PMUSA was focused in its impact in sustainable development. Although SUMP's are not enough for changing the path of GHG emissions, and so global warming, can be a great contribution by the local level for their reduction. Additionally, in order to successfully implement PMUSA, partnerships must be established between governments, national and local authorities, and civil society, hence the implementation of SDG 17 within the actions.

The plan clearly empowers the use of active mobility, which is good for the population's health, it presents an opportunity to reduce road casualties, to achieve the target set by the plans to reduce GHG emissions (8 per cent of 84756 ton CO₂), to reduce congestion and to provide the population with an efficient and sustainable transportation network. However, the habits of the population are the main players in this part. It is crucial to educate the population about climate change and how their behaviours can have a true impact against or for it.

The possible problem in PMUSA is not the plan itself but its implementation. In order to make the plan work and completely change the habits of the city regarding transportation, the actions must be totally implemented in due time and with the capacity to answer to the population's needs, and with an integrated format. In order to change the routines of the population in their mobility lifestyle to public-transportation and active mobility, services must answer efficiently on demand. Besides, the information should be available and up to date. The opportunity in integrated mobility for each user to design their route, according to their needs and preferences, with an attractive price and easy purchase, and according to the services available in that time, can create a real change on the population's behaviours – Mobility as a Service is the proposed solution.

5.2. Future Developments

In order to analyse the full implementation of PMUSA, here are the actions for further development of the present dissertation:

- Follow-up of the project Aveiro STEAM city and how it will be impacting transportation management;
- Follow-up on the implementation of the bike-sharing project and if the numbers of stops and bikes answer to the demand of the city;
- Re-evaluation of the public bus management and, if handled by the municipality, how it will be pursued;
- Analysis of the campaigns and educational material for the people of the city, to educate them to change their habits for the environmental footprint of the city;
- Analysis of the management of parking and if it is accordingly to the suggestions of the European Commission for Sustainable Urban Mobility.

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Appendix A

Appendix A

In Figure 18, it is possible to find a map from PMUSA where the roads of level 1 and level 2 can be identified. The level 1 roads are the purple full lines, while the level 2 roads are the purple pointed line (Município de Aveiro, 2015).



Figure 18 - PMUSA's differentiated roads, level 1 and level 2 (Município de Aveiro, 2015)