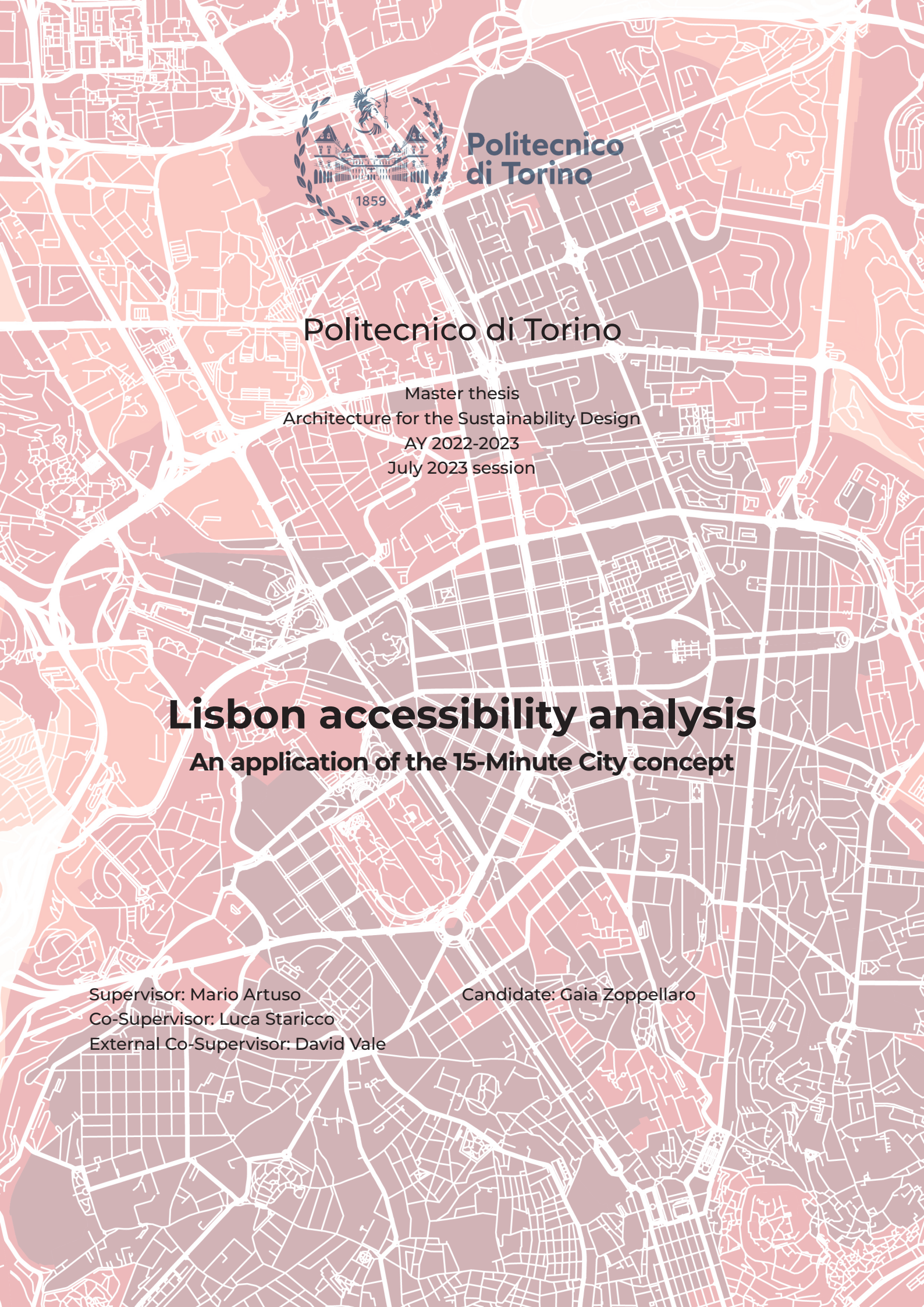

Politecnico di Torino

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Master thesis
Architecture for the Sustainability Design
AY 2022-2023
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Lisbon accessibility analysis

An application of the 15-Minute City concept

Supervisor: Mario Artuso
Co-Supervisor: Luca Staricco
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Abstract

The concept of the 15-Minute City has its roots in past planning theories, but has received increasing attention in recent years, especially following the outbreak of the global pandemic. This emergency situation has highlighted the importance of neighbourhood-based services that can be reached by active travel modes. This work aims to investigate the 15-Minute City concept applied to the city of Lisbon, highlighting its shortcomings, strengths and possibilities for future development. The study is divided into six main parts. The first chapter gives an overview of the 15-Minute City concept dealing especially with its relation to active mobility and is mainly based on scientific publications. The second chapter discusses cities that have adopted this strategy worldwide and analyses documents from three case study cities where the concept has been made operational. The third chapter focuses on the case study of the city of Lisbon, analysing the stratification of the city at the administrative level and the existing tools for urban mobility planning and management. The fourth chapter adopts a methodology developed by Professor David Vale of the University of Lisbon to operationalise the concept of the 15-Minute City and to analyse Lisbon's accessibility. The objective is to show the percentage of the population that has access to certain services through the pedestrian and bicycle network, within the time thresholds of 5-, 10- and 15-minutes, and the portions of the city where these services are lacking or in excess. The fifth chapter critically compares the methodologies used and the results obtained in this study and in a scientific article on the city of Turin (Staricco, 2022). The last part focuses on the neighbourhood scale, studying accessibility in relation to the elderly population (over 65) and identifying some neighbourhoods in Lisbon where some services are lacking. Finally, neighbourhoods are identified and some activities are reallocated to currently disused areas to show how the percentage of the population that can access them changes. The objective is to propose a solution that can have a concrete application on the territory and to show how the concept of the 15-Minute City can be implemented, adapting it to the context of reference.

Key-words

Accessibility – 15-Minute City – 20-Minute Neighbourhood – Active travel – Walking – Cycling – Walkability – Cyclability – Spatial equity – Built environment – Urban design – Geographic information systems

Table of contents

List of Tables

List of Figures

Abbreviations

AM	Área Metropolitana (AML: of Lisbon, AMP: of Porto)
CAOP	Carta Administrativa Oficial de Portugal
CCDR	Comissões de Coordenação e Desenvolvimento Regional
CCFL	Companhia Carris de Ferro de Lisboa
CIM	Comunidades Intermunicipais
CML	Câmara Municipal De Lisboa
DGT	Direção-Geral do Território
EC	European Commission
ECF	European Cyclists' Federation
EEA	European Environment Agency
EIT	European Institute of Innovation and Technology
ELTIS	European Local Transport Information Service
EMEL	Empresa Municipal de Mobilidade e Estacionamento de Lisboa
ENMAC	Estratégia Nacional para a Mobilidade Ativa Ciclável
ENMAP	Estratégia Nacional para a Mobilidade Ativa Pedonal
GAPPA	Global Action Plan on Physical Activity
GHG	Greenhouse gas
HIA	Health Impact Assessment
IMOB	Inquérito à Mobilidade nas Áreas Metropolitanas do Porto e de Lisboa
IMT	Instituto da Mobilidade e dos Transportes
INE	Instituto Nacional de Estatística
IST	Instituto Superior Técnico
ITDP	Institute for Transportation & Development Policy
ITS	Intelligent Transport Systems
NUC	Neighbourhood Unit Concept
NUTS	Nomenclature of Territorial Units for Statistics
OSM	OpenStreetMap
PAICD	Plano de Ação Integrado para Comunidades Desfavorecidas
PAMUS	Plano de Ação Mobilidade Urbana Sustentável
PAR	Plano de Ação Regional
PARU	Plano de Ação de Regeneração Urbana
PATH	Partnership for Active Travel and Health

PEDU	Plano Estratégico de Desenvolvimento Urbano
PMT	Plano de Mobilidade e Transportes
POR	Programa Operacional Regional
SUMP	Sustainable Urban Mobility Plan
TEN-T	Trans-European Transport Network
TML	Transportes Metropolitanos de Lisboa
TUM	Technische Universität München
UIT	Unidades de Intervenção Territorial
UMF	Urban Mobility Framework
UMP	Urban Mobility Package
UN	United Nations
WHO	World Health Organisation

Introduction and structure of the research

Aims and Objectives

The research aims to investigate a practical application of the 15-Minute City concept, first introduced by Carlos Moreno (Associate Professor at Paris Sorbonne Business School) in 2016. This concept, although relatively new, has roots in past theories (like E. Howard's Garden City, C. Perry's Neighbourhood, etc.) and consists of planning urban space according to a logic of proximity, favouring walking and cycling over car use (Moreno et al., 2021).

More specifically, it involves guaranteeing residents access to six essential functions within a limited time threshold, on foot or by bicycle, to guarantee a high standard of living (Moreno et al., 2021).

This principle gained notoriety after the Covid-19 pandemic when the importance of basic services and activities close to homes was re-evaluated (Wainwright, 2023) and the urban design of cities was rethought to meet new needs.

Indeed, the impact of the global health crisis has highlighted how urban planning and design have a significant effect on health and well-being (Mackness, 2021). Isolation has forced people to stay at home, adopting strategies such as smart working and highlighting inequalities in access to essential services.

This series of events has led planners, researchers, public authorities, etc. to ask themselves what the most effective measures are to design more sustainable, inclusive and equitable cities in the current historical period.

According to assessments provided by the World Health Organisation (WHO), almost the entire world population (99%) inhales air containing high concentrations of contaminants that exceed WHO recommended limits (World Health Organization[WHO], 2019). These contaminants contribute to the development of respiratory disorders and various other diseases, posing a significant risk to health and life. In particular, particulate matter in outdoor air pollution in urban and rural regions has been linked to conditions such as stroke, cardiovascular disorders, lung cancer, and acute and chronic respiratory diseases (WHO, 2019).

In 2015, world leaders adopted an Action Plan to limit global warming, called the Paris Agreement, which came into force the following year. The agreement aims “to maintain the rise in the average global temperature well below 2°C relative to pre-industrial levels and to continue efforts to keep it to 1.5°C” (Consiglio europeo, 2022).
One of the actions envisaged by the United Nations to fight climate change and air pollution is the development of more sustainable, intelligent and healthy intercity and urban mobility to reduce greenhouse gas emissions (GHG) from transport (European Commission, 2021d), which today are the source of 22% of total greenhouse gases in Europe, as shown in Figure 1 (European Environment Agency [EEA], 2022).

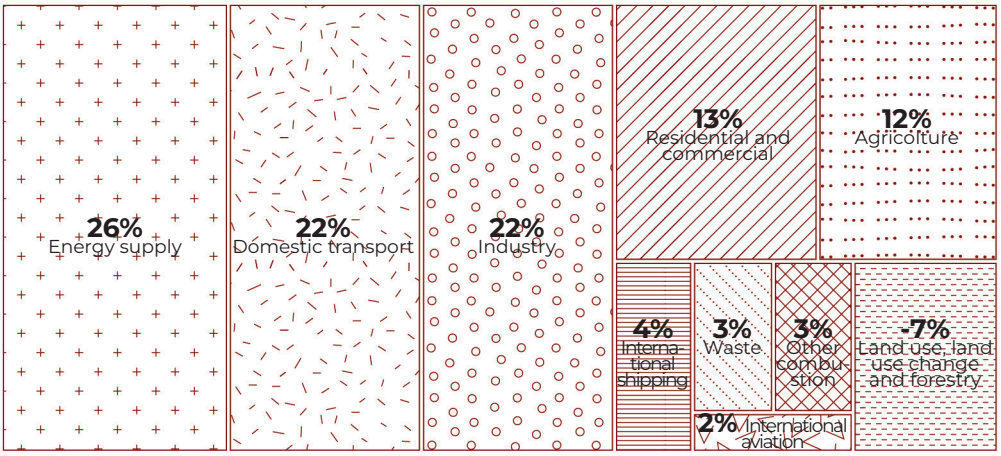


Figure 1. Sources of GHG emissions in EU
Source: European Environment Agency. (2022, November 28). *What are the sources of greenhouse gas emissions in the EU?* https://www.eea.europa.eu/signals/signals-2022/infographics/what-are-the-sources-of/view

Since the 1990s, several policies concerning urban mobility have been made by the European Commission. The new European Urban Mobility Framework (UMF) produced in 2021, part of a package of actions established by the European Commission (EC), proposes measures to provide citizens with more sustainable road transport, giving priority to active travel, public transport and connected and shared mobility services (European Cyclists’ Federation [ECF], 2022).
To respond with a strategy that relates built environment, active mobility and citizens’ habits, many administrations around the world have decided to adopt the concept of a 15-Minute City, a 20-Minute Neighbourhood or other variants with different time limits, framing it differently to their context (Gower & Grodach, 2022).

The fact that it is a recently developed theory, of which there are several variants, and that it is a theoretical model of which there are no clear guidelines concerning implementation, means that there is still no unambiguous application methodology.
This research aims to investigate a methodology for putting this concept into practice, applying it to the case study of Lisbon.
The city lends itself to the study, as it is an urbanised, compact and relatively dense urban centre (5 456.5 inhabitants/km²) (Câmara Municipal Lisboa, 2023). Moreover, despite being located on hilly terrain, most of the territory has a low slope, making it suitable for walking and cycling modes of transport (Câmara Municipal Lisboa, 2021). Another interesting feature of this study is that Lisbon has a large number of abandoned or decaying buildings, to which new functions could be assigned based on the 15-Minute City logic: analysing first of all where there is a shortage or overabundance of existing essentials services about the catchment area and proposing new allocations of them according to an intelligent distribution.
The importance given to proximity services is highlighted in the document produced by the *Câmara Municipal de Lisboa* "*Uma Praça em cada Bairro*" dating back to 2014, which promotes the redevelopment of public meeting spaces at the neighbourhood level and the modes of travel by foot, bicycle or public transport (Câmara Municipal de Lisboa, 2014).
Furthermore, within the most recent document "*Grandes Opções do Plano para 2023-2027*" produced by the *Câmara Municipal de Lisboa*, under the paragraph "*Urbanismo de proximidade*", the following measure to be adopted is indicated (no. 5): "To develop a practical application of the theoretical model of the "city in 15 minutes" that allows for the construction of a model of proximity urban functions (commerce, green and leisure spaces, education, culture and health) and the respective comfortable and safe pedestrian network for the city's neighbourhoods, through the "*Há vida no meu bairro*" Programme"(Câmara Municipal de Lisboa, 2022, pp. 23).
The municipality itself is therefore planning to implement this theory, but it is not mentioned how. It was therefore considered worthwhile to take Lisbon as a case study and analyse the amount of the population that has access to certain basic services at the neighbourhood level (19 were chosen) within 5-, 10-, and 15-minutes of walking or cycling. To obtain this data, a methodology learnt while participating in the course "Sustainable Urban Mobility" of the Master of Science

in Architecture course at the University of Lisbon, taught by Professor David Vale, was used. The course was followed during a 10-month mobility experience abroad, which gave an insight into the city and its dynamics.
Finally, it was decided to focus on a specific population group (the over-65s) to propose an application of this concept considering that people of different ages have different needs. The last chapter then reflects on the issue of equity and future implementations of this principle. For example, the accessibility of schools about their age groups could be analysed to understand where to develop new ones; or an analysis could be carried out to understand whether more or less serviced neighbourhoods correlate with the average income bracket of the population.

Main sources and research structure

The thesis is divided into 6 main chapters, the sources of which date almost entirely from the last 10 years.
The first chapter examined the existing literature on the topic of active mobility, accessibility and Carlos Moreno's 15-Minute City concept and its variants. Mainly articles published in scientific journals on the topics of transport, urban planning and geography were used. Relevant authors include B. van Wee (2022), C. Moreno (2021), D. Vale (2015, 2016), K. T. Geurs (2004), M. Kroesen (2022), R. Ewing (2010), R. Cervero (2010), and S. Handy (2014), of whom there is a brief profile at the end of this subsection. Sources include several books and websites, including the website of the European Commission and that of the World Health Organisation.
The second chapter analyses where the 15-Minute City principle has been put into practice around the world and explores its application in three reference case studies: Ottawa, Paris and Milan. Of particular interest are the two scientific articles consulted, one produced by A. Gower & C. Grodach (2022) and the other by European Institute of Innovation and Technology (EIT) Urban Mobility & Technische Universität München (TUM) (2022), which summarise the main locations where the concept has been adopted so far. For the analysis of the case studies, administrative documents produced by the respective municipalities and the corresponding websites were used.
The third chapter deals with the Lisbon case study, addressing briefly the city's evolution and the mobility planning and

management policies, with particular reference to the Sustainable Urban Mobility Plan (SUMP), adopted at the national, regional and local levels. The bibliography is mostly composed of legislative, administrative and strategic documents concerning urban mobility planning policies, produced by the European Commission, the *República Portuguesa*, the *Área Metropolitana de Lisboa* (AML) and the *Câmara Municipal de Lisboa* (CML). Subordinate to the documents, scientific articles on the topic were identified, the most relevant of which by the authors Lozzi & Monachino concerning active mobility policies in 4 European countries, including Portugal (2021). The open territorial data come from Eurostat, the statistical department of the European Union; from *Direção-Geral do Território* (DGT), an institute integrated into the direct administration of the Portuguese State; from *Geodados*, a platform of the *Câmara Municipal de Lisboa* that offers geographic data on the city. Finally, several websites were consulted, including Eltis, the Urban Mobility Observatory of the European Union; the World Health Organisation website (WHO); the National Statistics Institute of Portugal (INE); the Mobility and Transport Institute of Portugal (IMT).

The fourth chapter presents a method for operationalising the 15-Minute City concept, applied to the Lisbon case study. It draws on the work of Professors D. Vale and A. Lopes of the University of Lisbon for the methodology used, and on the work of Professor L. Staricco of the Politecnico di Torino, for the exposition of the results obtained. The spatial data needed for the accessibility analysis were obtained from the INE portal, and the OpenStreetMap (OSM) site, an open geographical database that allows free access to information.

The fifth chapter compares the work produced by Professor L. Staricco in the article “15-, 10- or 5-minute city? A focus on accessibility to services in Turin, Italy" (Staricco, 2022) with that produced in this thesis.

The sixth chapter focuses on the analysis of the accessibility of the city of Lisbon for the over-65 population. The main sources were some scientific publications, the most relevant on ageing in European cities (including Lisbon) produced by Arup, Help Age International, Intel & Systematica (2015); data on ageing trends in the world and Europe were sourced from the United Nations website (UN); finally, data on the over-65 population of Lisbon were sourced from INE and geographic information data from OpenStreetMap.

Relevant scientific authors

Regarding the bibliographic research part on the key topics of the 15-Minute City, accessibility and active mobility, the most relevant scientific authors are listed below.

Bert van Wee
Professor in Transport Policy, Delft University of Technology
Transport – Policy – Accessibility – Environment – Safety

Carlos Moreno
Associate Professor, Paris Sorbonne Business School
Cities – Urbanism – Sustainability – Complex Systems – Livable Cities

David Vale
Associate Professor, Universidade de Lisboa
Sustainable mobility – Accessibility – Walking – Cycling – Transport geography

Karst T. Geurs
Full Professor of Transport Planning, Dep. of Civil Engineering, University of Twente
Land use – Transportation – Accessibility – Evaluation and impact analysis – Sustainable mobility

Maarten Kroesen
Associate Professor, Delft University of Technology
Travel behaviour – Quantitative modelling – Active Travel – Health

Reid Ewing
Distinguished Professor of City and Metropolitan Planning, University of Utah
Urban planning – Transportation – Public health – Climate change – Urban design

Robert Cervero
Distinguished Professor of City and Regional Planning, University of California
Urban planning – Transportation planning – Sustainable development – Land use – Sustainable mobility

Susan Handy
Professor, Dep. of Environmental Science and Policy, University of California, Davis
Environmental policy – Land planning policy – Evaluation and impact analysis – Transportation – Cycling

Source: Google Scholar. https://scholar.google.com/

Chapter 1
The 15-Minute City

The chapter reviews the existing literature and is mainly composed of scientific articles published in journals on the subjects of urban planning, transport and geography.
It is divided into a first part dealing with active mobility and its relationship to the built environment; a second part defining the concept of the 15-Minute City, its characteristics and origins, and its particular notoriety following the Covid-19 pandemic; and a third part presenting the criticism to which this concept has been subjected.

1.1 Scientific background

The relationship between the built environment and urban mobility and accessibility is investigated in this sub-chapter, showing through scientific articles how they are closely interconnected concepts and which environmental factors can influence people's behaviour.
Physical activity, including walking and cycling, has health and well-being benefits and can be encouraged through the creation of safe and accessible places (WHO, 2022). The issue of accessibility is therefore of considerable importance as it has an impact on people's quality of life.
Several types of research are therefore cited that propose different methods to measure the pedestrian and bicycle accessibility of places. The concept of the 15-Minute City is among the studies that propose a strategy to increase pedestrian and bicycle travel methods through the modification of spaces and will be discussed in more detail in the following sub-chapter.

1.1.1 Relationship between Active Mobility, the Built Environment and Health Implications

In October, the World Health Organisation released the Global Status of Physical Activity Report 2022, which summarizes the progress made worldwide in putting the recommendations for increasing physical activity for people of all ages and abilities into practice (Global Action Plan on Physical Activity [GAPPA] policies), while also offering the first insight into the impact

of Covid-19 on countries' ability to implement these policies (WHO, 2022). According to estimates, 28% of adults worldwide do not engage in the recommended levels of physical activity, which would reduce the risk of premature death by 20–30% (Partnership for Active Travel and Health [PATH], 2022).

The report made by WHO outlines the four GAPPA strategies to increase physical activity: "create active societies, create active environments, create active people and create active systems" (WHO, 2022, pp. 14-15), and a set of indicators to achieve each of the policy action areas (WHO, 2022). The creation of active environments, in particular, results in safe and accessible places for all, through the integration of urban planning and transport planning, improved pedestrian and bicycle infrastructure and networks, increased access to open spaces and sporting activities, improved road safety, and a review of building design (WHO, 2022).

A special issue produced by Nocera and Attard (2021) collects 12 papers on the topic of social and health implications of active travel policies. The term active travel is generally used to define the actions of walking and cycling to the destination (Cheng et al., 2019; Kroesen and van Wee, 2022) or as part of a multimodal journey (Adamos et al., 2020). Several aspects are explored in the paper, including the importance of using a health and equity approach to achieve active travel policies, the positive impact of such policies on well-being in later life, and the consequences of the pandemic on people's travel habits (Nocera & Attard, 2021).

One of the most widely used approaches in research and practice to assess the potential health risks and benefits of public policies is the Health Impact Assessment (HIA) (Lozzi & Monachino, 2021). Yet, although active travel has been shown to influence population well-being and health, there are still few studies analysing how health strategies have been integrated into urban and transport planning (Lozzi & Monachino, 2021). Lozzi and Monachino aim to fill this gap with a paper that systematically analyses and compares the urban mobility planning policies of four European cities, evaluating the inclusion of parameters that assess the effects of these policies on health (2021).

A study by Kroesen and van Wee (2022) develops and estimates a structural equation model, based on aggregated data from 355 Dutch municipalities, with the aim of understanding which spatial characteristics most influence health through active travel (Kroesen and van Wee, 2022). The research relates demographic and spatial factors (socio-demographic

and economic characteristics; cycling infrastructure and accessibility) with behavioural factors (active and non-active travel; behavioural risk factors) to observe how they influence physical and mental health (Kroesen and van Wee, 2022).
The results show that the greatest effect on health is achieved by improving accessibility to schools (one of the four services considered), that the built environment is positively correlated with involvement in sporting activities, and that walking and cycling are negatively correlated with several diseases (Kroesen and van Wee, 2022).
Another study conducted in Greece seeks to identify the variables that affect travel behaviour by examining the impacts of active travel on health and quality of life. It is based on a questionnaire, demographic data, health background and habits and the results highlight the influence on the quality of life of behavioural beliefs and intentions, suitable infrastructure and good accessibility for the entire population (Adamos et al., 2020).
Considering the diversity of the population (gender, age, economic well-being, etc.) allows us to assess their different possibilities and needs concerning active travel. Some researchers, using different methodologies, have focused on a specific population group to make a specific analysis: Gorrini et al. examine women's accessibility to walking in New York City (2021), Cheng et al. examine how the built environment in Nanjing, China affects the active travel habits of older people and young adults (2019), Vale et al. measure and represent pedestrian accessibility in the city of Lisbon, comparing that of individuals with physical impairments versus those without disabilities (2016).

1.1.2 The Walkability Concept

One of the factors influencing active mobility is therefore the built environment (Vale et al., 2015), but what are its relevant characteristics that influence travel behaviour? One of the most frequently cited evaluation methods is the 3Ds ("Density", "Diversity" and "Design") proposed by Cervero and Kockelman in 1997, to which the parameters of "Destination accessibility" and "Distance to transit", and finally "Demand management" and "Demography" were later added (Ewing & Cervero, 2010).
Another concept that is often mentioned about this topic is "Walkability", of which, however, there is no unambiguous definition shared by researchers. Forsyth (2015) explores several studies to shed light on the concept: some of them focus on "the

ways or circumstances that make a place walkable, including its cross-sectionality, compactness, physical attractiveness, and safety" (Forsyth, 2015). Others consider walkability to be about "the benefits of walkable neighbourhoods, such as how they promote activity and socialization, offer sustainable transportation options, or encourage exercise" (Forsyth, 2015). Walkability is also understood as "a multifaceted and quantifiable element that contributes to improving urban environments or offering a comprehensive response to a variety of urban problems" (Forsyth, 2015).
Moura et al. refer to walkability as the level of urban environment's friendliness toward pedestrians (2017), questioning which indicators are appropriate to measure the pedestrian accessibility and attractiveness of a place and emphasising the importance of a participatory approach to deciding on such indicators (Moura et al. 2017). These include pedestrian characteristics, trip motives, urban context, and other cultural and environmental factors (Moura et al. 2017).
There are therefore limitations to the subject of walkability, both concerning its definition and the methodology used to assess it. On the one hand, there is uncertainty about the spatial unit to be considered (buffers, administrative boundaries, etc.), on the other hand, there is the subjectivity of researchers in choosing the parameters to be used to objectively calculate walkability. For this reason, it is not always easy to compare different studies on the topic (Shashank & Schuurman, 2019).

1.1.3 Bicycle Mobility and Accessibility

As explained above, active mobility includes not only the action of walking but also cycling. Several strategies can be used to assess how people cycle: determining the number of cyclists in a given location (place-based approach), conducting population surveys to establish their habits on how they travel (person-based approach) or combining both methods (Handy et al., 2014). These methods have their limitations, as it is difficult to separate cycling trips made for travel from those made for sport or recreation. Cycling for travel is influenced by a multitude of parameters: distances, bicycle infrastructure, bicycle assessment, bicycle equipment, costs, individual factors and social environment, and these can be assessed using both qualitative and quantitative approaches (Handy et al., 2014).
The Institute for Transportation & Development Policy (ITDP)

has developed a tool, called "The Grow Cycling Toolkit", which summarises a series of actions under the categories of infrastructure, policies, and education/awareness-building, and which aims to improve conditions for cyclists and increase their ridership (2020). Each of these actions is evaluated in terms of impact, time and cost so that they can be compared and evaluated (ITDP, 2020).
The importance of cycling as a method of travel, alongside walking, public transport and sharing mobility services, has also gained greater visibility in recent years from a political perspective. 2021 was an important year for cycling in Europe, in which several initiatives were launched, including: "Women in cycling", "Money for bikes", "Cyclists love trains" and the "Efficient and Green Mobility" package by the EC (European Cyclists' Federation [ECF], 2020). This was followed by the annual world cycling conference Velo-city 2021 in Lisbon and the European conference EuroVelo & Cycling Tourism Conference 2021 in Barcelona. Furthermore, thanks to the commitment of 350 organisations, active travel was recognised in the COP26 transport declaration. In the same year, the Pan-European Cycling Master Plan was adopted, a plan to promote cycling as a means of transport, which envisages the adoption of a national cycling strategy by 2030 by the 54 signatory countries, including 27 EU Member States (ECF, 2020).

1.1.4 Relationships with modern strategies that enhance the above content

As previously mentioned, there are benefits of promoting active mobility and accessibility, which can be seen in improved public health, both physical and mental (WHO, 2022); reduced traffic congestion, resulting in reduced travel costs (both temporal and monetary) and emissions from car use; improved air quality and reduced noise pollution (Mackness, 2021; Whitzman et al., 2013). In addition, the adoption of policies that prioritise walking and cycling results in increased road safety and a reduction in traffic accidents (Calafiore et al., 2022; Abdelfattah et al., 2022); and greater social equity, given the possibility of use regardless of physical ability, age and economic conditions (PATH, 2022).
Achieving these benefits, therefore, requires strategies that integrate environmental, social, economic and health aspects. Furthermore, the focus on active travel should not preclude the use of other means of transport, which in turn are necessary, but understand what combinations are best for an optimal result in terms of liveability.

A concept that encompasses these aspects and aims to achieve these benefits is the 15-minute city; by modifying the built environment it promotes increased walking and cycling, through a logic of proximity of essential services at the neighbourhood level (Gaglione et al., 2022; Moreno et al., 2021; Pozoukidou & Chatziyiannaki, 2021). This principle will be illustrated in the following section.

1.2 The 15-Minute City concept: from its origins to today's scientific debate

1.2.1 The accessibility issue

Concerning the correlation between the built environment and active mobility implies talking about accessibility. Capasso Da Silva et al. (2019) define the concept of urban mobility as "our ability to travel", while the concept of accessibility as "the ease of reaching destinations" (Capasso Da Silva et al., 2019). The two concepts are related and for this reason, sometimes the difference is not clear. Focusing on solutions that only concern mobility or prioritise can be a limitation and can produce side effects that negatively affect accessibility; for example, the construction of a highway can quickly connect two locations far apart, but at the same time be a barrier between two parts of a city (Handy, 2020).
It is therefore important to define the term accessibility, Geurs and van Wee in an article published in 2004 describe it as "the extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations using a (combination of) transport mode(s)" (Geurs & van Wee, 2004). Accessibility is thus influenced by four components: land use, transport, time and individual, the last of which is in turn affected by the person's socio-economic and demographic factors, attitudes and preferences, specific flexibilities, capabilities and social network (van Wee, 2022). Other important aspects to consider are perceived accessibility, which may differ from that calculated from spatial data, digital access, which may allow people to have access to/be aware of certain opportunities in a different way from traditional ones, and the context in which one is located (van Wee, 2022).
In general, different methodologies, variables and scales are used to measure walking and cycling accessibility, which

makes it difficult to compare them. Vale et al. (2015) analysed and compared 80 works concerning operational measures of active accessibility and found that, despite the huge number of methods used, they can be divided into the categories of "infrastructure-based, gravitational-based or distance-based and walkability/walk-score types" (Vale et al., 2015). Common limitations are highlighted: the unavailability of data, which often depends on open source or municipal databases; topography, important aspects such as slope are often not considered; the use of street centrelines, which reduces road's complexity; the scale of analysis, different scales may lead to different results; and the focus on the origin and not on the destination, which may preclude relevant aspects related to behavioural habits (Vale et al., 2015).

1.2.2 The 15-Minute City concept

One of the recent strategies that want to find an alternative to the car-centric vision with which cities are designed today and to respond to urban zoning policies that discourage social interactions (e.g., leading to some monofunctional neighbourhoods used only for housing), is the 15-Minute City concept. It was conceived by Carlos Moreno (Associate Professor at the Paris Sorbonne Business School) in 2016 but gained notoriety after the Covid-19 pandemic when Paris Mayor candidate Anne Hidalgo campaigned in 2020 and proposed the principle's application in the city to meet new needs (Moreno et al., 2021).
The application of this theory on a global level is taken up and deepened in the second chapter, where the case study of Paris is also examined.
The concept argues that essential facilities and services should be accessible to the inhabitants of a place within a time frame of 15 minutes from home, in the case of high population density, by walking or cycling (Balletto et al., 2021; Caselli et al., 2022). In the case of low population density, on the other hand, the time threshold is set at 30-minutes, also using other means of transport to make the trips (e.g., shared electric cars). The two-time thresholds are not rigid, but serve as an indication, and should be adapted to the characteristics of the city in which they are applied (Circonomia, 2023).
To ensure a good quality of life, Moreno thinks that citizens should be able to access six basic functions: "living", "work", "commerce", "health care", "education" and "entertainment" (Moreno et al., 2021).

These functions may be more or less relevant depending on the characteristics and complexity of the location in which they are found; therefore, the choice to consider and prioritise which ones should be adapted to the context (Ferrer-Ortiz et al., 2022). To define which of these functions should be prioritised, Moreno supports the importance of consultation between citizens, associations, political decision-makers, municipal technicians, businesses and the economic-productive sector. Adopting this approach allows the population to understand the 15-Minute City tool and actively participate in their city's planning by engaging with different stakeholders (Circonomia, 2023).
On 5 June 2023, at the second UN Habitat Assembly, the "Global Observatory of proximities" was launched, presented a year earlier at the 11th session of the World Urban Forum (WUF11) in Katowice, Poland (C40 Cities Climate Leadership Group, 2023a). The Observatory serves as a global platform to promote good practices and information exchange of local proximity-based initiatives. The founding members are the Entrepreneurship, Technology and Innovation Chair of the IAE Paris Sorbonne Business School (Chaire ETI), C40 Cities, United Cities and Local Governments (UCLG) and the United Nations Human Settlements Programme (UN-Habitat) (C40 Cities Climate Leadership Group, 2023a; C40 Cities Climate Leadership Group, 2023b). The platform aims to develop a model for the application of the 15-minute city concept (and other proximity-based theories) that is provided with official parameters and can guide local policymakers' implementation (C40 Cities Climate Leadership Group, 2023a; C40 Cities Climate Leadership Group, 2023b).

1.2.3 The evolution

The idea of a "15-Minute City" is not brand-new but takes some elements from earlier studies, such as Howard's Garden City, dating from the late 19th century (Staricco, 2022). Howard's vision consists of a central city spreading radially over other smaller interconnected cities surrounded by green belts, thus combining the best aspects of the country and city (Sharifi, 2016). His ideal community would have a socially diverse and active population, working together to run the city for the good of all (Sharifi, 2016).
A further theory in which common aspects can be found is the Neighbourhood Unit Concept (NUC), introduced by Clarence Perry in the early 1920s (Caselli et al., 2022). It describes the neighbourhood unit as a core of the city, defining the urban

services it should have (schools, public facilities and places of worship in the centre and shops on the edges) and a set of quantitative measures (population, population density, range of neighbourhood activities, etc.) that would promote a safe pedestrian environment and human interactions (Caselli et al., 2022; Pozoukidou & Chatziyiannaki, 2021).

The New Urbanism movement also takes up the NUC theory, which dates back to 1979 (Kissfazekas, 2022). The goals are to minimise walking distances primarily through compact distribution and medium to high housing density, and to meet everyday needs by placing the neighbourhood as the basic unit of spatial organisation through mixed land use (Caselli et al., 2022; Pozoukidou & Chatziyiannaki, 2021).

Transit-Oriented Development is a theory that developed concurrently and absorbs many aspects of New Urbanism, mainly developed by Peter Calthorpe in 1993 (EIT Urban Mobility & TUM, 2022). Briefly, it involves the reorganisation of spaces by favouring proximity to stations for pedestrians, through increased density around these places and the development of urban and green areas that encourage human contact (Sharifi, 2016).

The temporal conditions belonging to the concept of the 15-Minute City are also not new but were introduced by Torsten Hägerstrand in 1970 in Time Geography (Mocák et al., 2022). Hägerstrand proposed a theory that considers the dimensional limits of space concerning time limits and the human condition. Reflect upon the fact that moving from one place to another consumes time, that human activities have a certain duration and cannot be located in several places simultaneously, and that this implies some constraints (Mocák et al., 2022).

Other similarities to the 15-minute city can be found in Walter Christaller's Central Place Theory of 1933, Harris and Ullman's Multiple Nuclei Model (polycentric city) of 1945, Jane Jacobs' Urban Vitality approaches of 1961, Human Scale urban design by Christopher Alexander and Jan Gehl of 1987 and Eco-urbanism principles of the 2000s (EIT Urban Mobility & TUM, 2022; Ferrer-Ortiz et al., 2022; Staricco, 2022).

Moreno also refers to his concept as "chronourbanism", taking up the principles of the theory introduced by François Ascher in 1997 (Moreno et al., 2021).

The research published by Khavarian-Garmsir et al. in 2023 summarises and describes the main theories from which the concept of the 15-Minute City originates and compares the following aspects: "proximity", "density", "diversity", "mixed-use",

"modularity", "adaptability", "flexibility", "human-scale design", "connectivity" and "digitisation" (Khavarian-Garmsir, 2023).
Table 1 integrates the planning principles reported in this article and those reported in the publication produced by EIT Urban Mobility & Technical University of Munich (2022), maintaining the same comparison categories as the former.

Table 1. 15-Minute City-related theories (black dots indicate the presence of common characteristics, white dots the absence)
Source 1: Khavarian-Garmsir, A. R., Sharifi, A., Abadi, M. H. H., & Moradi, Z. (2023). From Garden City to 15-Minute City: A Historical Perspective and Critical Assessment. Land, 12(2), 512. https://doi.org/10.3390/land12020512
Source 2: EIT Urban Mobility & TUM. (2022, November 30). Urban Mobility Next 9. ±15-Minute City: Human-Centred Planning in Action. EIT Urban Mobility. https://www.eiturbanmobility.eu/wp-content/uploads/2022/11/EIT-UrbanMobilityNext9_15-min-City_144dpi.pdf

	Proximity	Density	Diversity	Mixed-Use	Modularity	Adaptability	Flexibility	Human-Scale Design	Connectivity	Digitalization
Garden city (1898)	○	○	●	○	○	○	○	○	●	○
Neighbourhood Unit (1926)	●	○	○	○	○	○	○	●	○	○
Polycentric city (1945)	○	○	●	●	●	○	○	○	○	○
Time geography (1970)	●	○	○	○	○	○	○	●	○	○
New Urbanism (1979)	●	●	●	●	○	○	○	●	●	○
Transit Oriented Development (1993)	●	●	●	●	○	○	○	●	●	○
Chronourbanism (1997)	○	○	○	○	○	●	●	●	○	○
Eco-urbanism (2000s)	●	●	●	●	○	●	○	●	●	●
15-Minute City (2016)	●	●	●	●	●	●	●	●	●	●

1.2.4 The 20-Minute Neighbourhood

A variant of the 15-minute city theory is the 20-minute neighbourhood, a concept that originated in the city of Portland in the United States (Whitzman et al., 2013). The Portland Plan defines that essential services (housing, groceries, schools, open spaces and transportation) should be accessible to all at the neighbourhood level within a 20-Minute timeframe, ideally on foot, or otherwise by bicycle, public transport or car (Capasso Da Silva et al., 2019; Whitzman et al., 2013). Although they are similar concepts, it should be pointed out how the definition of neighbourhood or city (of the 15/20 minutes) gives a different connotation to the meaning, considering the smaller and local scale of the former, which defines self-sufficient areas within the city, and the larger scale of the latter (Staricco, 2022).
The concepts of the 15-Minute City and its variant of the 20-Minute Neighbourhood have been cited and analysed in several studies, applying different methods of analysis but with a common focus on the temporal dimension. The different methodologies generally employ buffer analysis, isochrone maps or closest facility analysis (Caselli et al., 2022).
Among the studies adopting the 20-Minute City or Neighbourhood principle, we can mention the following: (a) Capasso Da Silva et al. present the case of Tempe, Arizona, evaluating the accessibility of the city by walking, cycling and public transport and concluding that the city presents good accessibility, despite being highly car-dependent (2019); (b) Calafiore et al. perform an accessibility analysis on the Liverpool City Region, UK, using a methodology that also assesses social inequalities (2022); (c) Thornton et al. present an operational methodology applied to case studies of the Australian cities of Melbourne (Victoria) and Adelaide (South Australia) (2022).

1.2.5 The equity issue

The pandemic crisis due to Covid-19 has highlighted some shortcomings in city planning, amplifying social and economic inequalities due to the poor accessibility of some parts of cities to basic services. The reason can be found, at least partially, in modernist urban planning theories. Giving primary importance to the automobile has created a connected urban fabric, but the liveability of the city has become a marginal issue (Moreno et al., 2021).

The issue is not new; as early as 2013, Bernardo Secchi speaks of a "New Urban Question", highlighting how contemporary cities, although different from each other, have a common aspect of heterogeneity and fragmentation and will face common problems in the future: social inequalities, climate change, and urban mobility and accessibility. Secchi points out how, after a crisis, the city changes its spatial structure, relationships, functioning and image (2013). Spatial planners and government thus play a decisive role, as decisions that affect the spatial configuration of the territory have direct consequences on the society that inhabits it. Indeed, spatial policies can result in phenomena of exclusion and intolerance, or on the contrary, solidarity (Secchi, 2013).
The 15-Minute City concept, like the 20-Minute Neighbourhood concept, aims to equalise access to basic community services and in its future developments should therefore consider the pluralities and different needs of the population living in the city. For example, elderly people will have different needs than children and adults (Moreno et al., 2021).
An increasing number of studies are being developed on the topic of spatial equity related to the Walkability of neighbourhoods, considering, for example, the income, education level and nationality of the resident population and correlating them with the accessibility of neighbourhoods, to test whether there are phenomena of exclusion and spatial segregation (Weng et al., 2019).
The term "equity" applies to several fields of study, with meanings that may vary. In the field of transport, it can be understood mainly in two ways: "horizontal equity", in which there is a uniform distribution of services among similar individuals or groups, and "vertical equity", or social justice, in which the distribution of services is based on the different needs of the population, favouring those with fewer opportunities (Guo et al., 2020). The term "equity", therefore, is understood as a fair distribution, based on the diversity of the population, and differs from the term "equality", which instead indicates a homogeneous distribution of services to the entire population (Guo et al., 2020).

1.2.6 Environmental, economic and social achievements and Benefits

The academic paper produced by Allam et al. explores the concept of the 15-Minute City and highlights its benefits regarding sustainability, collecting the findings of numerous

studies and comparing the concept to other urban planning theories emerging in recent years (2022).
Figure 2 summarises the main sustainability benefits that are highlighted in this study.

Figure 2. Benefits the 15-Minute City has on sustainability
Source: Allam, Z., Bibri, S. E., Chabaud, D., & Moreno, C. S. (2022). The Theoretical, Practical, and Technological Foundations of the 15-Minute City Model: Proximity and Its Environmental, Social and Economic Benefits for Sustainability. *Energies, 15*(16), 6042. https://doi.org/10.3390/en15166042

The study relates the four main aspects of the theory (proximity, density, diversity and digitisation) with the achievable environmental, economic and social benefits, focusing on the importance of the human dimension in city design (Allam et al., 2022).
Through planning policies that promote proximity in cities, it is possible to reduce the pollution and congestion produced by car travel in favour of shorter journeys on foot or by bicycle. Furthermore, the consumption of local products contributes to the reduction of greenhouse gas emissions (Allam et al., 2022).

Within the theory, the concept of density is revised by Allam et al. in favour of the compact city, through the optimisation of resources and the intelligent distribution of services across the territory (2022). The element of diversity is understood both as mixed land use, as a diversification of housing types, and as a social mix, to foster integration between people with different cultures, backgrounds and income levels. The instrument thus aims to reduce the socio-economic segregation of some neighbourhoods from others.
Finally, digitalisation can help reduce emissions through new technologies (e.g. energy efficiency of buildings) and improve the citizen experience through the use and collection of data (Allam et al., 2022).

1.2.7 The scientific debate and some critical positions

The concept of the 15-Minute City has received some criticism from researchers and experts on the subject. These criticisms mainly relate to the fact that the 15-Minute City, being based on the principle of proximity and the enhancement of services at the neighbourhood level, may increase segregation and spatial exclusion if cities are not planned according to the principle of equity.
The aim of this principle is the opposite, through an analysis of the city's accessibility it is possible to identify the poorest and least served neighbourhoods, to prioritise intervention in urban planning programmes for making access to services more equitable (C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2023).
Carlo Ratti, in a study with Harvard professor Ed Glaeser, emphasises the importance of ensuring that low-income people can travel outside their neighbourhood to access opportunities in other parts of the city (Ratti & Muggah, 2023).
In the Boston Globe article, "The pushback against the 15-minute city" (2023) C. Ratti argues that the goal of the 15-Minute City is not to create "autonomous enclaves", but to provide essential services within 15-minutes and to create more flexibility, so that long commutes are not compulsory, but rather dedicated to activities that do not take place daily (to cite one example: going to the stadium). Another element highlighted is the advantage of meetings and the exchange of ideas done in person, as opposed to online, which would be stimulated by the implementation of this principle (Ratti & Muggah, 2023).
Geolocation of essential services in many cities has been in the past and still is today a social justice issue. This problem can be addressed, for example, through the active participation of

citizenship, highlighting the different needs to make essential services truly accessible also to the most fragile people (EIT Urban Mobility & TUM, 2022).

The creator of the concept, Carlos Moreno, in an interview produced by the Aspen Institute (2020), answers a question about implementing the city concept in 15-Minutes to achieve the same results in high-income and low-income neighbourhoods.

Moreno argues that it is necessary to develop not only the mix of urban social functions but also social housing, through new rules and regulations based on the management of the common good. He cites the example of Paris, where it was decided to distribute 25 per cent of social housing in all neighbourhoods (including social housing, cultural centres, shopping centres, pedestrian streets, digitisation, green spaces, bicycle lanes and multi-social activities) to avoid new segregation based on money or gentrification (The Aspen Institute, 2020).

It is important to map and profile who lives in the city (young people, families, the elderly, etc.) to understand which services should be provided and those that are lacking, designing them accordingly to the people living in the different neighbourhoods (Circonomia, 2023).

In another interview, Moreno reiterates the concept and states how important it is to transform users, for example, according to a vision of local commerce as a common good of the area (RIBA Architecture, 2022). To realise these activities, it is necessary to have commercial real estate that has a lower rent than the speculative real estate market. In Paris, he argues, several city competitions have been launched to transform places and thus the uses of neighbourhoods to develop a social mix (RIBA Architecture, 2022).

Chapter 2
Reference case studies

The chapter first summarises a list of cities in which the 15-Minute City concept or its variants have been applied, based on two scientific studies; next, the application of this principle to three case studies is explored by analysing their administrative documents and comparing similarities and differences.
An article written by Alexa Gower (Postdoctoral researcher, Monash University) & Carl Grodach (Professor and Director of Urban Planning & Design, Monash University) examines 32 cities globally in which the concept of 20-Minute Neighbourhood, 15-Minute City or variants was implemented, to assess whether the documents of these cities have clear and measurable benchmarks (Gower & Grodach, 2022).
The planning documents analysed belong to the following 18 cities: Bendigo (Victoria, Australia), Melbourne (Victoria, Australia), Moonee Valley (Victoria, Australia), Sydney (Australia), Brampton (Ontario, Canada), Ottawa (Canada), Portland (Canada), Bogotà (Chile), Shanghai (Cina), Paris (France), Dublin (Ireland), Milan (Italy), Hamilton (New Zealand), Singapore (Singapore), Kirkland (Washington, US), Detroit (US), Eugene (Oregon, US), Tempe (Arizona, US) (Gower & Grodach, 2022). Another 14 cities, listed in the scientific article, were excluded due to a lack of information.
The research team applied a three-step process to analyse the documents of the 18 cities. They identified the type of document based on the content of policy implementation ("city strategic plan", "city statutory document" or "city marketing brochure"), tabulated the elements of the 20-Minute Neighbourhood concept according to 8 main themes and assessed the presence of clear objectives or benchmarks (Gower & Grodach, 2022). The analysis focused on implementation, definition and measurability to understand how cities operationalise the concept (Gower & Grodach, 2022).
In the first part of this article, cities are subdivided according to the type of planning document adopted (Table 2): (a) "city strategic plan" - strategic guidelines or actual planning policies; (b) "city marketing brochure" - marketing tool for the promotion of the city, which is, however, not adopted or integrated into the planning system (Gower & Grodach, 2022).

Table 2. Type of planning document
Source: Gower, A., & Grodach, C. (2022). Planning Innovation or City Branding? Exploring How Cities Operationalise the 20-Minute Neighbourhood Concept. *Urban Policy and Research, 40*(1), 36–52. https://doi.org/10.1080/08111146.2021.2019701

City strategic plan		
Bendigo, Australia	Ottawa, Canada	Singapore, Singapore
Melbourne, Australia	Portland, Canada	Hamilton, NZ
Mooney Valley, Australia	Shanghai, China	Kirkland, US
Sydney, Australia	Milan, Italy	Tempe, US

City marketing brochure		
Bogotà, Chile	Eugene, Canada	Dublin, Ireland
Brampton, Canada	Paris, France	Detroit, US

Gower & Grodach show that only 2 out of 18 cities - Portland and Eugene - have specific, measurable benchmarks that facilitate effective implementation and support sustainable planning. In contrast, most cities do not have measurable targets, resulting in an unclear and intangible adoption of the concept through strategic guidelines that lack legal weight and emphasise city branding (2022).

2.1 Application of the concept worldwide

The concept of the 15-minute city, and variants of the 20-minute neighbourhood, 10-minute neighbourhood, etc., are starting to be a measure adopted by several cities internationally as a response to the environmental problems and socio-sanitary challenges highlighted by the pandemic crisis when people were physically confined within a certain urban space and could not access all the services and activities (Figure 3).
These new models of urban living are developing, no longer mainly car-based, but with a more ecological and technological footprint, which promotes rethinking the spatial organisation of services according to a proximity logic and favours soft mobility (Caselli et al.; Ferrer-Ortiz et al.).
As an urban planning tool that has recently become widespread, it has yet to be investigated how it has been operationalised by different cities, with some cities using this theory by adopting specific and measurable targets, while others have made it a political slogan, without adopting actual measures to

implement it (Gower & Grodach, 2022).
As mentioned, the concept has expanded globally, especially in Europe and the United States, using both different spatial (neighbourhood, town, city) and temporal (10, 15, 20, 30 minutes) parameters (Figure 3). In Figure 3, the cities analysed in the studies by Gower & Grodach (2022) and EIT Urban Mobility & Technical University of Munich (2022) are grouped according to the time threshold that is adopted. There is no correlation between the dimensions of cities adopting one-time threshold versus another.
Understanding in which cities this theory (or its variants) has been implemented and what methodology is used is interesting because it demonstrates its global reach and can help to build a unified model of application, stimulate the exchange of information between different cities and share the best practices.
The Global Observatory of Sustainable Proximities aims to serve as a knowledge-sharing and advocacy platform for cities, bringing together scientific publications and non-scientific publications and initiatives that have been adopted around the world (C40 Cities Climate Leadership Group, 2023a). As it has only recently been launched, the website does not present an exhaustive list of initiatives like the publications used to elaborate Figure 3, while the section on academic articles is quite rich (C40 Cities Climate Leadership Group, 2023a).
In the following sub-chapters, the 15-Minute City implementation programmes of three cities shown on the map will be analysed to highlight commonalities and differences and compare them with each other. The choice of the cities analysed in this chapter was made based on the study by Gower & Grodach, (2022) and focus on Paris (classified as “city marketing brochure”), Milan and Ottawa (classified as “city strategic plan”) to compare different types of approaches.
Three cities that adopted the same time threshold of 15-minutes were chosen, as it is the limit studied and used in this research for the Lisbon case study.
Paris was the first city in the world to apply this principle, which (as already mentioned) gained notoriety after it was adopted by the Mayor of Paris Anne Hidalgo (Circonomia, 2023), and therefore it was considered interesting to examine its case study. The other two case studies were chosen from the list of cities that have implemented the strategy within their urban planning policies.

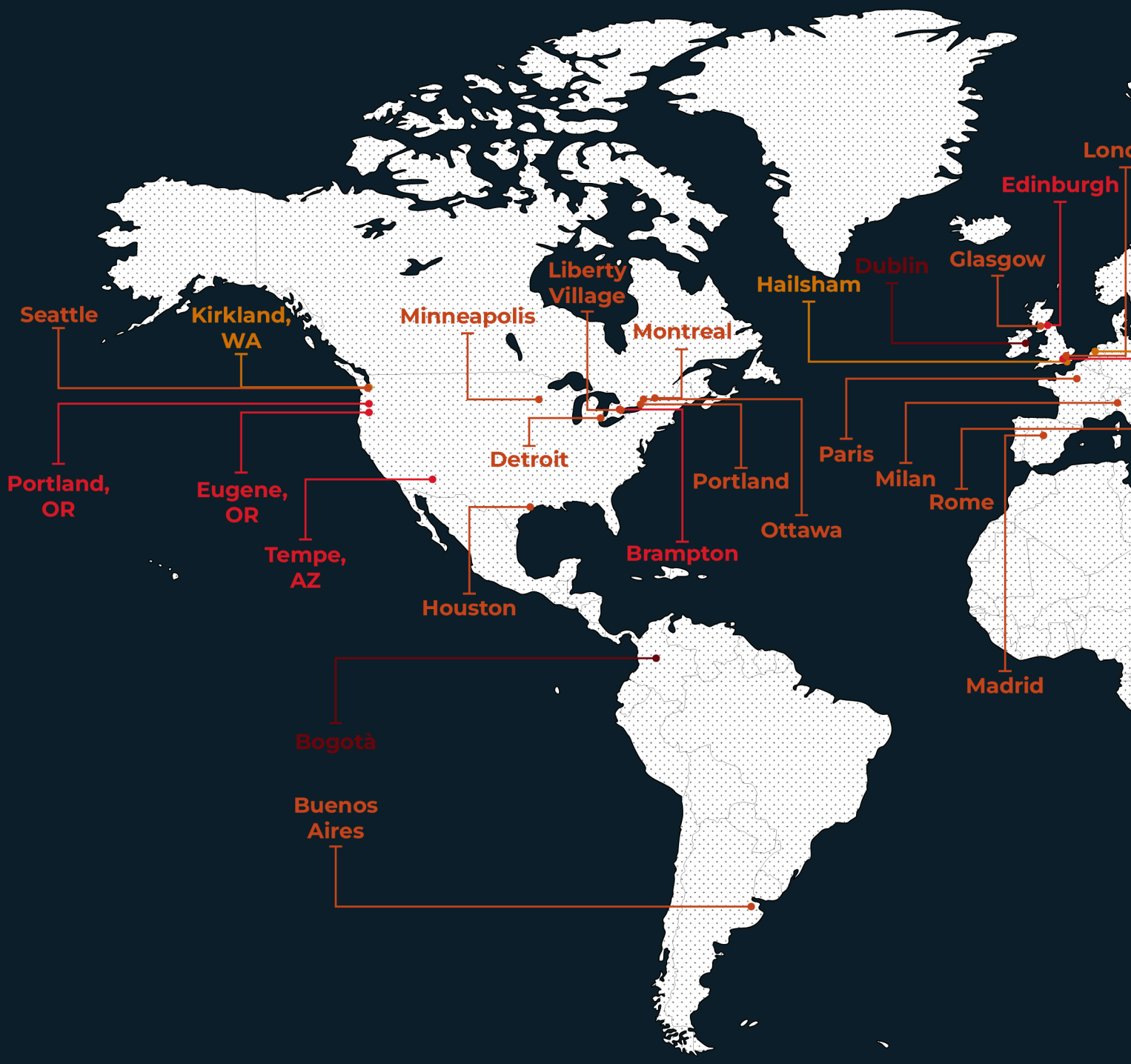
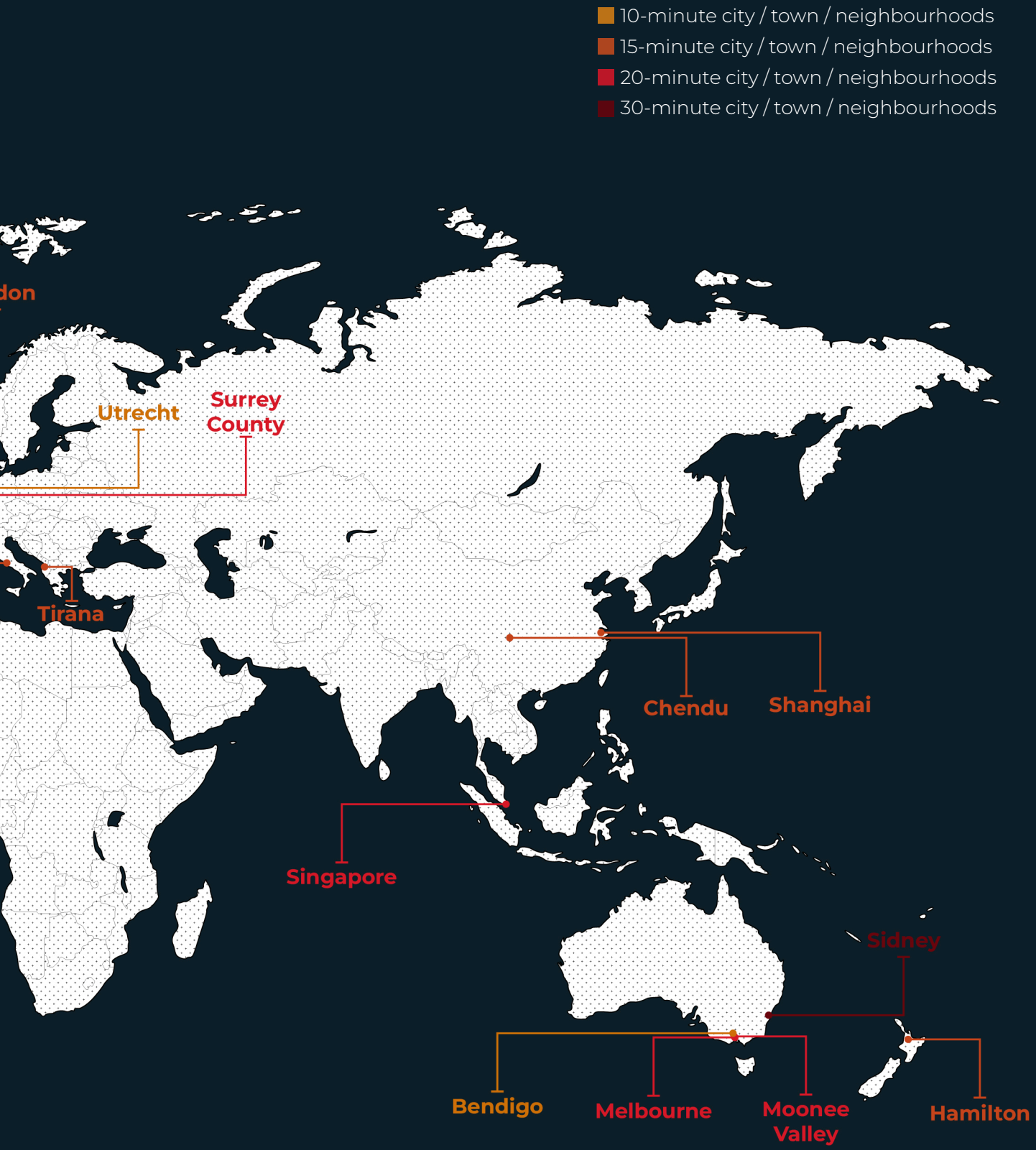


Figure 3. Cities where the 15-minute city concept, or its variants, have been applied
Source 1: EIT Urban Mobility & Technical University of Munich. (2022, November 30). *Urban Mobility Next 9.*
wp-content/uploads/2022/11/EIT-UrbanMobilityNext9_15-min-City_144dpi.pdf
Source 2: Gower, A., & Grodach, C. (2022). Planning Innovation or City Branding? Exploring How Cities Ope
g/10.1080/08111146.2021.2019701



±15-Minute City: Human-Centred Planning in Action. EIT Urban Mobility. https://www.eiturbanmobility.eu/

erationalise the 20-Minute Neighbourhood Concept. *Urban Policy and Research*, *40*(1), 36–52. https://doi.or

Furthermore, comparing cities of different dimensions, population density and contexts can demonstrate the flexibility of adaptation of the 15-Minute City concept and illustrate how implementation methodologies respond to different local realities. Paris is a compact city with a high density of inhabitants, Milan is also a compact and relatively dense city and is similar in size and density to the Lisbon case study, while Ottawa has a lower density of inhabitants and is, therefore, more spread out over the territory (Government of Canada & Statistics Canada, 2023; Insee, 2022; Istat, 2023).

2.2 Paris

The city of Paris has an area of approximately 100 km^2, more than 2 million inhabitants and a population density of around 20'000 inhabitants/km^2 (Insee, 2022).
As has been mentioned before, the 15-Minute City concept was promoted by Anne Hidalgo while running for mayor in 2020. The municipality of Paris adopts the concept of the "*Ville du quart d'heure*" by transforming existing places into spaces that can accommodate more activities than originally planned, rather than by creating new ones (Circonomia, 2023). Central to this process are culture, schools and participatory democracy (Figure 4).
Schools are being reinvented as multifunctional spaces where free play and recreational activities can take place outside of class hours; school, college and kindergarten playgrounds, therefore, remain open to the public on Saturdays during set hours to make schools the core of the district and an element of recreation for families (Alberti & Radicchi, 2022).
Since January 2021, this experiment has been implemented in 71 school buildings and has met with success among families, fostering exchange and integration among citizens (Ville de Paris, 2022a).
Culture becomes a central element through the development of "*plateaux artistiques*", entertainment venues for professional and amateur artists in the different neighbourhoods. Participatory democracy, on the other hand, is translated into the creation of "*kiosques citoyens*", spaces where locals can meet, discuss and receive help from city officials or associations (Alberti & Radicchi, 2022; Ville de Paris, 2022a).
In December 2021, the "*Pacte parisien de la proximité*" was adopted, which entrusts more decision-making power to

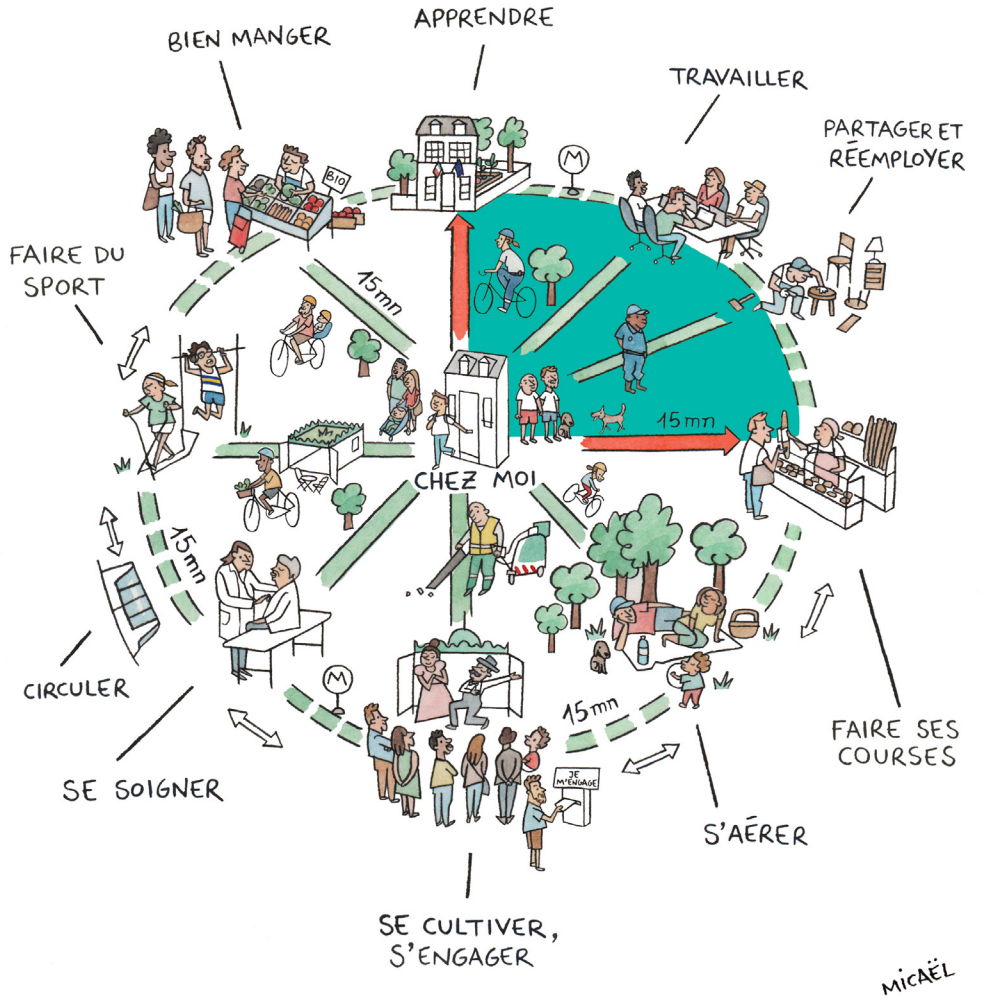


Figure 4. Le Paris du 1/4 heure
Source: Paris en commun (2020). Le Paris du 1/4 heure. Micael. https://micaeldessin.com/Paris-en-commun

municipal mayors on issues of maintenance, renovation and embellishment of neighbourhoods, strengthens the Municipal Police body for each neighbourhood and establishes a fund for local events (Ville de Paris, 2022a).

Other initiatives include the establishment of "sport social clubs"where parents and children can practise a sporting activity near their home free of charge, or benefit from childcare; the strengthening of the network of shops and the promotion of local production (Ville de Paris, 2022a).

So far, the concept has been applied to four neighbourhoods: Les Olympiades, Vaugirard, Place des Fêtes and Porte de Montmartre (Ville de Paris, 2022a).

The city of Paris' adoption of the 15-Minute City concept does not present a specific methodology for analysing existing and missing facilities. However, consultation with citizens is considered of primary importance, and the identification

of certain neighbourhoods in need of extensive and rapid intervention is indicated as a future strategy, where an exhaustive analysis of existing or to-be-built local facilities and services, whether public, associative or private, should be carried out (Ville de Paris, 2022a).
The City of Paris also has a "*Plan Local d'Urbanisme*" (PLU), which was adopted in 2020 and establishes the city's land uses (Ville de Paris, 2022b). The plan was revised in June 2023 so that it would respond to the challenges of climate change and is referred to as the "*Plan d'Urbanisme Bioclimatique*" (Ville de Paris, 2023b).
The plan's objective is to transform Paris into a more inclusive city, preserve its cultural and environmental heritage, reduce carbon emissions, encourage commercial and craft diversity and cooperate with neighbouring territories (Ville de Paris, 2023b).
Following the diagnosis phase, there was a consultation phase with citizens and stakeholders to define which interventions were a priority. Among the guidelines produced for designing the city is the strategy "*Le quartier du quart d'heure*" (Ville de Paris, 2023b). The main proposals of this strategy are to encourage the establishment of local activities, combat predatory economy phenomena, increase social housing (including cultural and sporting activities), the creation of new health centres, and increase green space and sporting activities in certain working-class neighbourhoods (Ville de Paris, 2023a).
In 2021, the City of Paris also adopted the "*Plan vélo 2021-2026*" a cycling plan that envisages the creation of 180km of new lanes (compared to more than 1000km existing), continuity of the lanes with those of neighbouring municipalities, improved safety, and an increase of 130'000 new bicycle parking spaces, to encourage people to use the bicycle as a method of travel and pleasure (Ville de Paris, 2021).

2.3 Milan

The city of Milan has an area of approximately 180 km^2, more than 1 million inhabitants and a population density of around 7'400 inhabitants/km^2 (Istat, 2023).
Even before the pandemic, in 2018, the City of Milan launched the "*Piazze Aperte*" project, which aims at urban regeneration, sustainable mobility and the enhancement of public space (Comune di Milano, 2023). Through tactical urban planning interventions, redundant streets and intersections are

transformed into new public spaces. 65 intervention proposals have been collected from associations, citizens and public bodies, which are currently in the co-design phase (Alberti & Radicchi, 2022; Pinto & Akhavan, 2022). The programme is based on the involvement and collaboration of citizens to manage and maintain the new spaces (Comune di Milano, 2023). The success of the first temporary squares led to permanent arrangements (Alberti & Radicchi, 2022; Comune di Milano, 2023; Pinto & Akhavan, 2022).

On the theme of proximity, in 2019 the "*Piano dei Quartieri*" and the "*Bando Quartieri*" were published by the Municipality of Milan, and finally in 2020 the "Milan 2020. Adaptation Strategy"(Alberti & Radicchi, 2022).

In the document "Milan 2020. Adaptation Strategy" produced by the Municipality of Milan in 2020, the 15-Minute City is mentioned as one of the strategies to be undertaken to respond to the needs arising from Covid-19 and to revalue the neighbourhood dimension (Comune di Milano, 2022a). Figure 5 summarises the proposals and actions in this document. Among the proposed actions is the strengthening of the proximity of services to guarantee less inequality in neighbourhoods, creating new health centres in collaboration with the Lombardy Region, with attention to the weakest areas, supporting local commerce and guaranteeing the use of digital services for all (Comune di Milano, 2022a; Pinto & Akhavan, 2022).

Figure 5. Proposals and actions of Milan2020. Adaptation Strategy
Source: Comune di Milano. (2022a, June 20). *Milano 2020.* Comune Di Milano. https://www.comune.milano.it/aree-tematiche/partecipazione/milano-2020

To promote the city of 15 minutes, in 2022 the Municipality of Milan has published the call "*Mi15 - Spazi e Servizi per Milano a 15 minuti*" with specific guidelines for the realisation of projects aimed at activating or enhancing spaces or services with a social impact that are absent or insufficient in the neighbourhoods (Comune di Milano, 2022b). A series of parameters were thus defined: eligible applicants, available financial resources, guidelines on the content of project proposals, evaluation criteria, and project timelines (Comune di Milano, 2022b).
The financial resources earmarked for Mi15 projects amount to €1,351,322, and each project can receive between €24,000 and €80,000 (a contribution corresponding to 80% of the total cost, with 20% to be covered by the company). In addition, there is a reward system (which provides for a remuneration of €51,322.00 in total) for deserving companies that undertake a social impact assessment and then reach the pre-established targets (Comune di Milano, 2022b). The evaluation is carried out through indicators (Key Performance Indicators) associated with the projects by an external evaluator. It is also defined how the monetary contribution is spendable, i.e. which expenses are eligible and which are not (Comune di Milano, 2022b).
The call is aimed at Micro, Small and Medium Enterprises (MPMI), which can only submit one application each, and proposals must meet the requirements of usefulness, durability and accessibility to be eligible. This translates into outdoor, playful, cultural, social, sporting, entrepreneurial, circular economy, healthy eating and wellness activities (Comune di Milano, 2022b).
Proposals may be located in all districts of the city, except for the Zona 1 "*Centro Storico*" municipality, and must respond concretely to local needs, paying particular attention to fragile contexts and individuals (Comune di Milano, 2022b).
The evaluation criteria are based on the characteristics of the proposing party and the adequacy of the team, the quality and feasibility of the proposal, the expected social impact, economic and financial sustainability and follow-up. Each application is awarded a score from 0 to 100 points, with a minimum eligibility threshold of 65 points (Comune di Milano, 2022b).

2.4 Ottawa

The city of Ottawa has an area of approximately 2 800 km2, more than 1 million inhabitants and a population density of around 360 inhabitants/km2 (Government of Canada & Statistics Canada, 2023).

The 15-Minute Neighbourhood concept is part of the “Five Big Moves” introduced in 2019 with the drafting of the new Official Plan of the City of Ottawa, Canada, which addresses the issues of growth, mobility, urban design, resilience and the economy (City of Ottawa, 2021).
The accessibility of the city of Ottawa was analysed through a study that considers spatial planning and the pedestrian environment. The purpose of this study is mainly to create a service/facility base within a 15-minute walk from homes, as well as to assess whether the related pedestrian routes are safe and pleasant, with a view to future developments (Lu & Diab, 2023).
The process consists of a first part of public consultation and a second part of existing conditions assessment (service and facility scores, pedestrian environment scores and score combination).
The first phase of the public consultation took place in the summer of 2020, with a meeting with the working group of Official Plan Ambassadors (OP), who explained which services they thought should be included in the 15-minute neighbourhood study. Based on the results, an online public survey was then conducted, with 4’000 responses, to assess which services citizens considered to be a priority in the neighbourhoods, which were missing, whether they were accessible, and which elements affected pedestrian safety and liveability (City of Ottawa, 2021). Finally, a further online survey was conducted in rural areas to understand the specific needs of residents in these areas (City of Ottawa, 2021; Lu & Diab, 2023).
The second phase of the public consultation took place in spring 2021, first with a meeting with the working group of OP Ambassadors and then with the general public, to present the first results of the analysis, gaps, methodology and next steps. The meetings served to highlight the most important topics for future surveys and improvements to be made regarding equity and inclusion issues (City of Ottawa, 2021).
The surveys highlighted the priority services for citizens, from the most relevant: “grocery stores, parks, retail, public transport bus stops, health services, train stations, indoor recreational and community facilities, elementary and secondary schools, and childcare facilities” and highlighted the importance of safe walking and cycling paths and pavements (City of Ottawa, 2021; Lu & Diab, 2023, pp. 9).
The first step in the evaluation of existing conditions was to geolocate services within the city, creating a 15-minute walk (1200 metres) network around each residential parcel and

assigning each residential parcel a score from 1 to 9, one point for each service or amenity present within a 15-minute walk (City of Ottawa, 2021). Another map was then created using the same method, but assigning a different score to the various services, based on the priorities highlighted in the survey. Finally, starting from the previous map, the concentration of services within a 15-minute radius for each of the nine categories was considered relative to the total number of activities in the city. The final map was then simplified into three accessibility categories by grouping the scores: high, moderate and low accessibility (City of Ottawa, 2021).

The second stage of the process was to assess the safety and enjoyability of the streets, starting with questionnaires that highlighted citizens' priorities: maintenance of pavements and footpaths, safe crossings and traffic protection measures (City of Ottawa, 2021).

Artificial intelligence (AI) was then used to obtain walkability values for commercial streets and a qualitative assessment of built character and form was developed, dividing the streets into urban, hybrid urban, hybrid suburban and suburban. Therefore, using the creation of a safety index and a pleasure index, a quantitative geographic information system (GIS) analysis was conducted on the presence of pleasant and unpleasant elements within 30 metres of the centre of a road (City of Ottawa, 2021). The indices were combined, weighted differently according to the public survey responses, to calculate a final pedestrian environment score for each stretch of road, which was then simplified into a map dividing the pedestrian environment values into high, moderate and low (City of Ottawa, 2021).

The final service access/amenities and pedestrian environment maps were combined into one to provide a basis for planners to identify gaps and opportunities to improve the pedestrian network (Figure 6). Next steps were identified for each scored area, considering that the city is constantly changing and the analysis will need to be updated in the future, that some data may be inaccurate or missing, and that external stakeholders from the private sector will need to be involved to understand market trends (City of Ottawa, 2021).

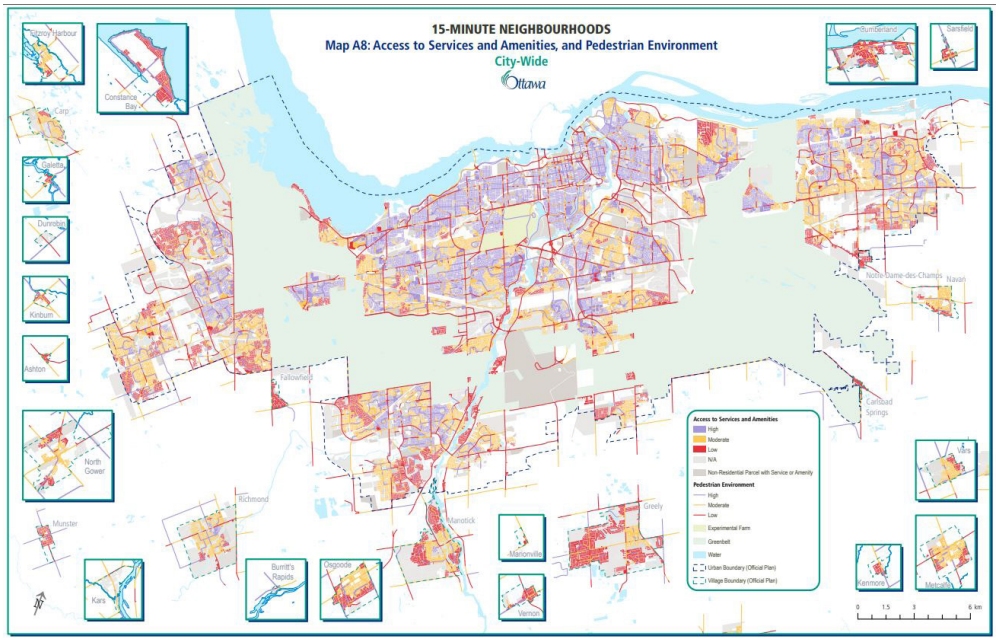


Figure 6. Access to Services and Amenities, and Pedestrian Environment of the City of Ottawa
Source: City of Ottawa. (2021, September 27). *15-minute neighbourhoods. Ottawa*. https://engage.ottawa.ca/the-new-official-plan/news_feed/15-minute-neighbourhoods

2.5 Comparison between the case studies

Comparing density and urban scale, Paris appears to be a very dense and compact city whose infrastructure and existing urban fabric favour the application of the 15-Minute City concept. Milan, on the other hand, is also relatively dense and has a compact structure that lends itself to having services and facilities within walking distance of homes. Ottawa, finally, is a larger site than the previous ones and for this reason, there is a special part of the process dedicated to the implementation of the concept in rural areas (Government of Canada & Statistics Canada, 2023; Insee, 2022; Istat, 2023).
The three urban areas adopt the principle of the city in 15 minutes in different ways: Paris by transforming existing spaces to accommodate more activities than originally planned and focusing on culture, schools and participatory democracy (Ville de Paris, 2022a); Milan, by implementing the concept through calls for tenders, which therefore have a fragmented character (Alberti & Radicchi, 2022). The last one aimed at Micro, Small and Medium Enterprises for projects that activate or improve services and spaces with a social impact in neighbourhoods (City of Milan, 2022b); Ottawa by incorporating the concept in its

Official Plan, analysing accessibility through a study on spatial planning and pedestrian environments (City of Ottawa, 2021). Each city emphasises the importance of involving citizens in the process: Paris creates permanent structures in the city for discussion between administration and citizens; Milan through welcoming initiatives and collaborations from citizens; Ottawa through targeted involvement of the population in the first phase of the programme (City of Ottawa, 2021; City of Milan, 2022b; Ville de Paris, 2022a).

When comparing which functions were included in the 3 approaches, it can be seen that all 3 cities included the promotion of local businesses and food, and Milan opened its call for business; education was included by all and Ottawa specified the level of schools needed; working from home was only considered in Milan's strategy; proximity to public transport was included by all and Ottawa specified the creation of multimodal stations; the promotion of walking and cycling was included by all and Ottawa and Milan indicated how (more green, safety and traffic calming); the inclusion of social housing was considered by both Ottawa, Milan and Paris; green spaces were considered by all but Ottawa also indicated the amount of useful space per person (City of Ottawa, 2021; City of Milan, 2022a; Gower & Grodach, 2022; Ville de Paris, 2022a).

Milan and Ottawa, unlike Paris, define in detail how the city concept is to be implemented in 15 minutes in official documents. The city of Paris, however, is working on remaking the *Plan Local d'Urbanism* from a more ecological perspective and proposing the use of the 15-Minute City concept as a strategy (Ville de Paris, 2023b).

Ottawa, finally, is the only one of the three cities in which a methodology for assessing the existing conditions and lack of services in neighbourhoods is defined and explained in detail, measuring accessibility, safety and use of streets (City of Ottawa, 2021; Lu & Diab, 2023).

In all three cities, however, no clear and measurable benchmarks are established outlining the results to be achieved (e.g. the percentage of citizens who should have access to the chosen services within a given year).

Chapter 3
Case study: the city of Lisbon

The chapter introduces the case study of this thesis, the city of Lisbon, describing briefly the evolution of the capital from its origins to nowadays, through documents and sources found online mainly from the Câmara Municipal De Lisboa; the second part investigates the mobility planning policies adopted at different scales - city, metropolitan area and nation -, especially the Sustainable Urban Mobility Plans (SUMPs) are examined, concerning European directives. The administrative subdivision of the country is also described to understand which bodies are in charge of implementing these plans. For this second part, the majority consulted legislative, administrative and strategic documents concerning urban mobility planning policies; in the minority, scientific articles; and finally, open territorial data obtained from websites such as Eurostat, Direção-Geral do Território (DGT) and Geodados CML.

3.1 General overview of Lisbon evolution

3.1.1 A brief overview of the City's Development

The first traces of Lisbon date back to the first millennium B.C. when the first populations settled in the city, attracted by the Tagus River and the defensive hills. Over the centuries, Lisbon has experienced various dominations and periods of economic growth (Câmara Municipal de Lisboa, 2020c).
Between the 7th and 8th centuries B.C., Phoenician populations settled in the area and contributed to the city's growth through port activities, mining, livestock breeding and local industries. The Romans later took up residence in Lisbon in 138 B.C. and built walls around the Roman town hall located on the hill. In the 5th century A.D., the Visigoths took power and in 714 the city was handed over to the Moors (Câmara Municipal de Lisboa, 2020c).
In 1147, Lisbon became a Christian city when it was integrated into the newly founded Kingdom of Portugal by D. Afonso Henriques. The city continued to grow as an economic centre, especially in trade and crafts.(Oliveira & Pinho, 2010).
In the 14th century, Lisbon experienced a great territorial expansion and in the 15th century, it began to develop as one

of the world's major commercial centres. The city attracted citizens and foreigners, which led to the expansion outside the city walls and the beginning of subdivision (Câmara Municipal de Lisboa, 2020c).

In 1650, architect João Nunes Tinoco produced the first topographical survey of Lisbon (Figure 7) (Câmara Municipal de Lisboa, 2020c). In 1755, a violent earthquake followed by a tsunami and fires caused the destruction of a large part of the city and the death of many people. The Marquis of Pombal created a reconstruction plan approved in 1758, which resulted in the Centro Pombal, characterised by narrow streets and standardised buildings (Figure 8) (Oliveira & Pinho, 2010).

During the 19th and 20th centuries, Lisbon experienced moments of political instability, with the Napoleonic invasion in 1810 and regime changes. In 1856, the first railway was inaugurated. In 1910, the Republic was proclaimed, followed by a military coup in 1933 that led to a dictatorial regime. During this period, important urban projects were realised, including the Portuguese Universal Exhibition of 1940 and the Lisbon General Urbanisation Plan of 1948, which reflected the trends of the international modernist movement (Câmara Municipal de Lisboa, 2020b).

In 1974, with the Carnation Revolution, democracy was established in Portugal. In the following years, Lisbon faced challenges and promoted strategic plans to raise the standard of living for the population. In 1992, the Lisbon Strategic Plan was approved, followed by the 1994 Municipal Master Plan, which promoted urban regeneration, the protection of environmental and landscape values and the redevelopment of river areas (Câmara Municipal de Lisboa, 2020b; Oliveira & Pinho, 2010).

In 2012, a strategic planning process was initiated to enhance neighbourhoods, entrepreneurship, modernity and innovation, and administrative reform of the municipality reduced the number of freguesias to 24 (Figure 11). With a focus on urban regeneration, the promotion of walking and cycling routes, the creation of green spaces, and cultural diversity, Lisbon has transformed into a cosmopolitan, multicultural, and inclusive city (Câmara Municipal de Lisboa, 2020b).

Figure 9 shows the evolution of Lisbon through the centuries, from the 14th century to the present situation.

Figure 7. Historical cartography produced by João Nunes Tinoco in 1650
Source: Câmara Municipal de Lisboa. (2017b, March 10). *Cartografia Historica Tinoco 1650*. Geodados CML. https://geodados-cml.hub.arcgis.com/maps/cartografiahistorica-tinoco-1650/

Figure 8. Historical cartography produced by Carlos Mardel in 1756
Source: Câmara Municipal de Lisboa. (2017c, March 10). *Cartografia Historica Carlos Mardel 1756*. Geodados CML. https://geodados-cml.hub.arcgis.com/maps/cartografiahistorica-carlosmardel-1756/

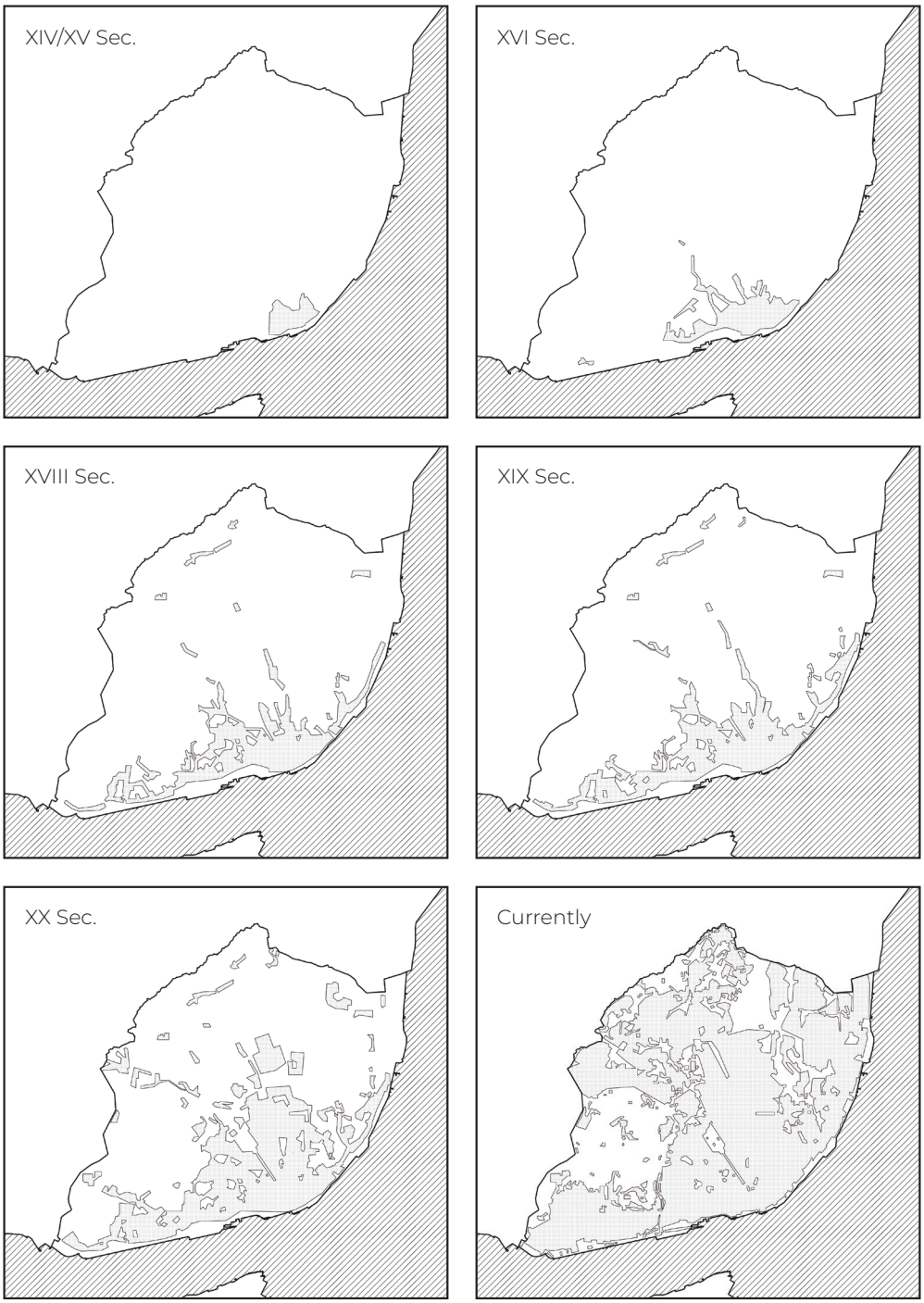


Figure 9. Evolution of the city over the centuries
Source: Câmara Municipal de Lisboa. (2014). Uma Praça em Cada Bairro. In *Câmara Municipal De Lisboa*. https://www.lisboa.pt/fileadmin/cidade_temas/urbanismo/espaco_publico/praca_cada_bairro/Uma_praca_em_cada_bairro_enquadramento.pdf

3.1.2 The City's Relationship with Neighbourhoods, Public Space and Mobility

Lisbon rose organically around the Castle of São Jorge and has undergone planned interventions throughout its history; it is defined as a city of neighbourhoods and for this reason is characterised by a fragmented and diversified urban fabric (Marluci, 2019; Oliveira & Pinho, 2010). It differs from other European cities as the neighbourhoods are organised in a heterogeneous manner, with pre-Pombaline grids on the hills, regular Pombaline layouts in the Baixa area and post-Pombaline neighbourhoods such as Avenidas Novas and Alvalade (Oliveira & Pinho, 2010).

Historically, Lisbon's neighbourhoods have been home to communities of different ethnic, religious or regional origins, creating neighbourhood connections and a sense of belonging (Marluci, 2019). The centre of Lisbon, Baixa Chiado, was the political, administrative, economic, financial, religious and cultural heart of the city, although it never became residential (Câmara Municipal de Lisboa, 2014).

Houses were usually close to essential services, which favoured walking. The historical neighbourhoods such as Alfama, Castelo, Mouraria, Bairro Alto and Madragoa maintained a strong neighbourhood cohesion due to their morphology and low motorisation rate (Câmara Municipal de Lisboa, 2014).

The expansion of the city and its densification were favoured by the network of trams in the 20th century, which ensured the mobility of residents. However, the city centre emptied as central functions were decentralised to new areas. The concentration of commerce in department stores, the widespread use of the car and direct access to housing reduced neighbourly relations, causing the isolation of people in their own homes (Câmara Municipal de Lisboa, 2014).

The relocation of industries and services has led to the emigration of residents to neighbouring municipalities, further emptying the centre of Lisbon. The structure of the city was influenced by the accessibility of the different city attractions and the means of transport used (Câmara Municipal de Lisboa, 2014).

The adaptation of the city to the needs of the private car led to the specialisation of streets to favour car traffic and parking, leaving deep scars in the urban landscape (Câmara Municipal de Lisboa, 2014).

In the 1970s, a strong movement emerged to reclaim public

space from pedestrians, promoting public transport, soft transport modes and bicycle networks. During the 20th century, mobility in Lisbon changed radically from the tram network to the predominance of the automobile. This led to a hierarchization of the road system and the construction of urban motorways, which created physical barriers in the urban landscape (Câmara Municipal de Lisboa, 2014).

Today, environmental sustainability requires a reduction in CO_2 emissions and also a reduction of the congestion. To decrease the environmental impact, it is necessary to favour public transport, active transport modes and sharing services, as well as to create an inclusive and green public space.

Figure 10. Historical cartography produced by Silva Pinto in 1911
Source: Câmara Municipal de Lisboa. (2017e, March 10). *Cartografia Historica Silva Pinto 1911*. Geodados CML. https://geodados-cml.hub.arcgis.com/maps/CML::cartografiahistorica-silvapinto-1911/

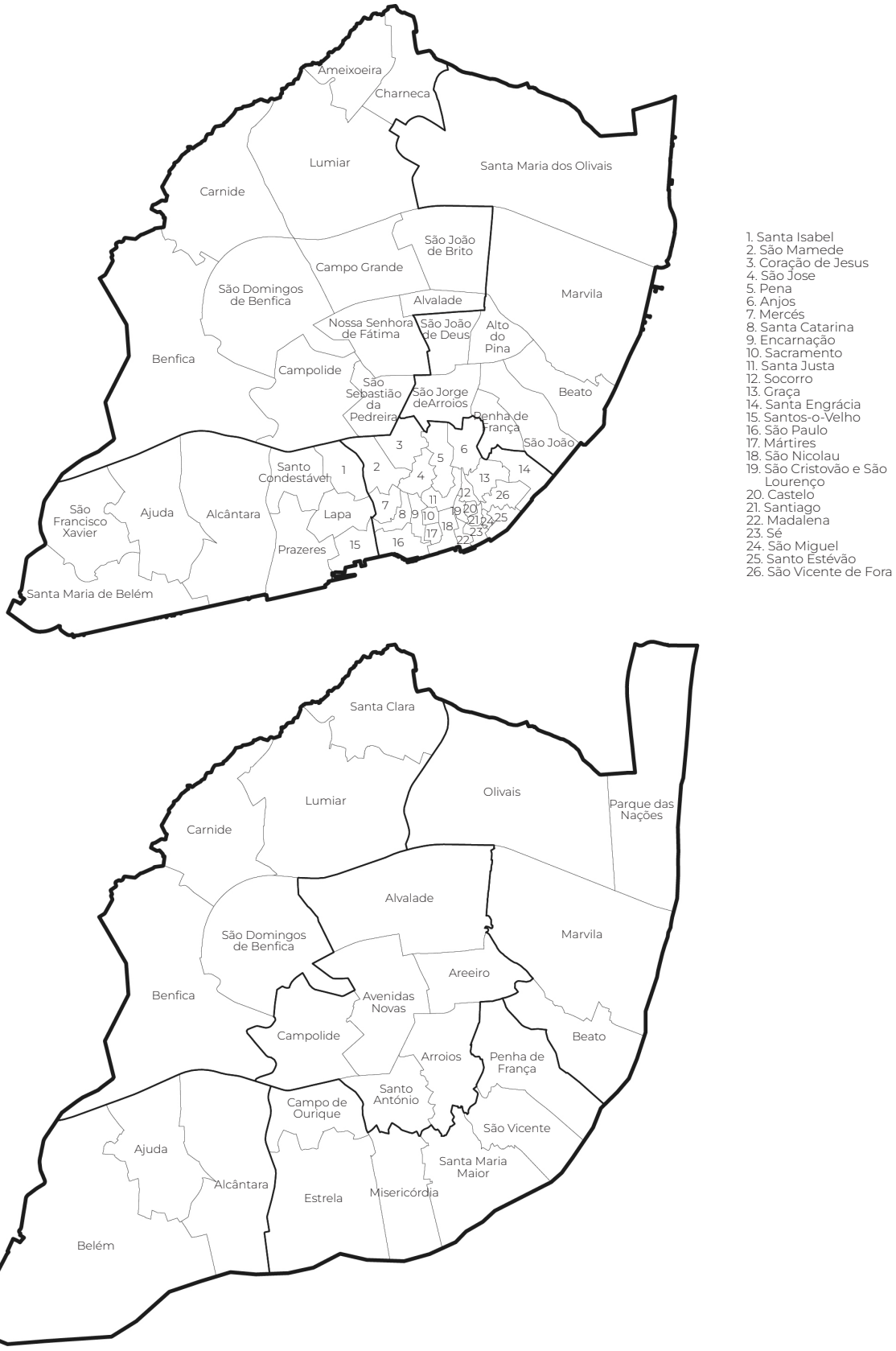


Figure 11. Lisbon Administrative Division before and after 2012
Source: Direção-Geral do Território. (2023, February 3). *Carta Administrativa Oficial de Portugal*. Direção-Geral Do Território. https://www.dgterritorio.gov.pt/cartografia/cartografia-tematica/caop

3.2 Urban mobility planning in the city of Lisbon

3.2.1 European Union Policies and Strategies on urban mobility

In 2009, the European Commission published the Action Plan on Urban Mobility, which deals with the topic of urban mobility as a means of contrasting air and noise pollution, congestion, health problems and demographic trends, growing in urban areas (Commissione europea, 2009). The Plan defines a framework for action until 2012 (at the EU level), to facilitate the adoption of initiatives by local, regional and national authorities in cooperation with each other (European Commission, 2009).
Then, in 2011, the White Paper on Transport, first published in 1992, was adopted by the EC to develop common policies for a transition to "sustainable mobility". To keep global warming below 2°C, the 2011 document set the target of "reducing greenhouse gas emissions in transport by at least 60% by 2050 compared to 1990" (European Commission, 2011).
During those years, the energy requirements of the transport sector in the EU were 96% covered by oil and its derivatives, there was a strong imbalance between the infrastructure development of eastern and western parts of the EU, and road and air congestion was a source of considerable accessibility problems (Commissione europea, 2011).
The document analysed aims to create a more competitive, sustainable and resource-efficient single European transport area, integrating different scales of intervention and promoting multimodal transport modes (European Commission, 2011).
The initiatives listed in the 2009 Action Plan on Urban Mobility were implemented on schedule and a new Action Plan was drafted by the EC in 2013, the Urban Mobility Package (Commissione europea, 2013).
The document highlights the importance of implementing measures in urban areas, as this is where 23% of CO2 emissions were produced by transport, where there were congestion problems, where environmental air quality values were above limits and where 38% of fatal road accidents were estimated (European Commission, 2013). A Eurobarometer survey carried out in 2013 showed that the majority of citizens surveyed considered this issue to be of primary importance.

In the new plan, the Commission encourages local governments to follow guidelines for creating and implementing Sustainable Urban Mobility Plans (SUMPs), emphasising the importance of cooperation between the different sectors involved, between neighbouring authorities and between different administrative and governmental levels (European Commission, 2013).
In 2019, the European Commission endorsed the Green Deal, whose main objectives are "to reduce greenhouse gas emissions by 50-55% compared to 1990 values by 2030" (already mentioned in the White Paper on Transport) (Commissione europea, 2019), to be the first climate-neutral continent by 2050 and to plant 3 billion trees by 2030 in the EU (Commissione europea, 2019; European Commission, 2021a).
To support the previously adopted Green Deal, in 2020 the EC adopted a Strategy for Sustainable and Intelligent Mobility, with the common goal of having a net reduction in emissions within the next 30 years (Commissione europea, 2020; European Commission, 2021b) and in 2021 adopted the New Urban Mobility Framework (European Commission, 2021c; European Commission, 2021d).
As mentioned earlier, the concept of SUMP was introduced by the European Commission in 2009 and a document was published in 2013 to provide Member States with guidelines to make it operational in cities.
In the version of the document updated to 2019, the definition of SUMP is given, Rupprecht Consult defines it as: "a strategic plan designed to meet the mobility needs of people and businesses in and around cities for a better quality of life. It builds on existing planning practices and gives due consideration to the principles of integration, participation and evaluation" (Rupprecht Consult, 2019, pp. 9).
SUMP is defined by European Union guidelines, then declined at the national scale and finally implemented at the local scale (Figure 12).

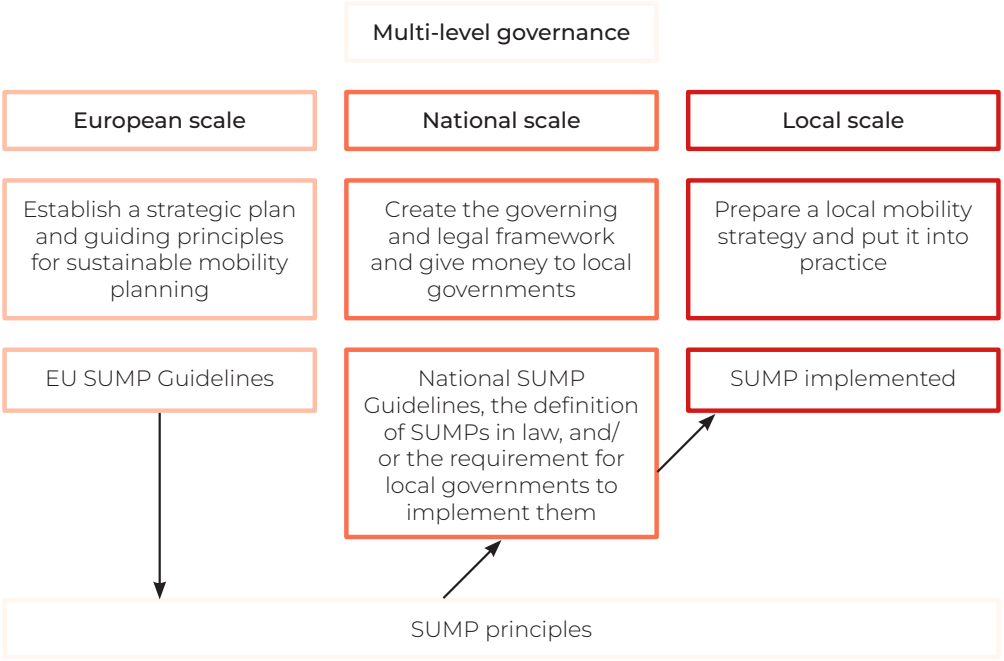


Figure 12. Multi-level governance of SUMPs in Europe
Source: Lozzi, G., & Monachino, M. S. (2021). Health considerations in active travel policies: A policy analysis at the EU level and of four member countries. *Research in Transportation Economics, 86*, 101006. https://doi.org/10.1016/j.retrec.2020.101006

3.2.2 Statistical and Administrative Division of Portugal

To understand how the SUMP instrument has been applied in Portugal, it is necessary to first explain the administrative division of the country.
Portugal, according to the 1976 Constitution, is made up of the continental territory on the mainland, and the Autonomous Regions of the Azores and Madeira (INE, 2021).
It is divided into sections by the "Nomenclature of Territorial Units for Statistics," a hierarchical system of statistical regions and sub-regions, a unique and coherent system for classifying the territory of the EU, which was introduced in the early 1970s by Eurostat and assumed legal status in 2003 (Eurostat, 2021).
This subdivision has three levels (Figure 13):

- NUTS I - large socio-economic regions (3);
- NUTS II - basic regions for the implementation of regional policies (7);
- NUTS III - small regions for specific diagnoses (25) (Eurostat, 2021).

This subdivision is only valid for statistical purposes, as in Continental Portugal at the administrative level several subdivisions coexist and sometimes lead to the duplication of services in the same areas (INE, 2021).

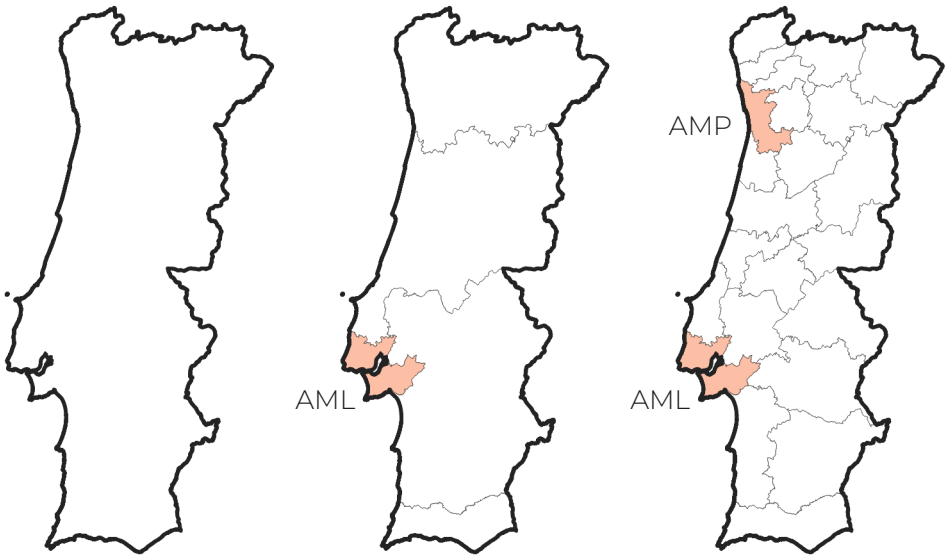


Figure 13. Statistical division of mainland Portugal according to NUTS I, II, III
Source: Eurostat. (2021, January 1). *GISCO: NUTS*. https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts

At the administrative level, Continental Portugal is divided into (Figure 10):

- *CCDR* - coordination and regional development committees that act as departments of the Central Administration, endowed with administrative and financial autonomy (5);
- *Áreas Metropolitanas e Comunidades Intermunicipais* - metropolitan areas of Lisbon and Oporto and inter-municipal communities, informal structures and networks between municipalities that do not have administrative validity, corresponding geographically to the NUTS III statistical subdivision (23);
- *Municípios* - municipalities representing the autarkic power and decentralisation of the State close to the population (308);
- *Freguesias* - civil parishes that are a fundamental part of municipal power (3092) (INE, 2021).

Another spatial planning management tool, in place since 2001, is the *Carta Administrativa Oficial de Portugal* (CAOP), which keeps track of the country's administrative districts' delimitation status. It is based on the information produced by censuses and is updated annually, the latest version dating back to the year 2021 (DGT, 2023).

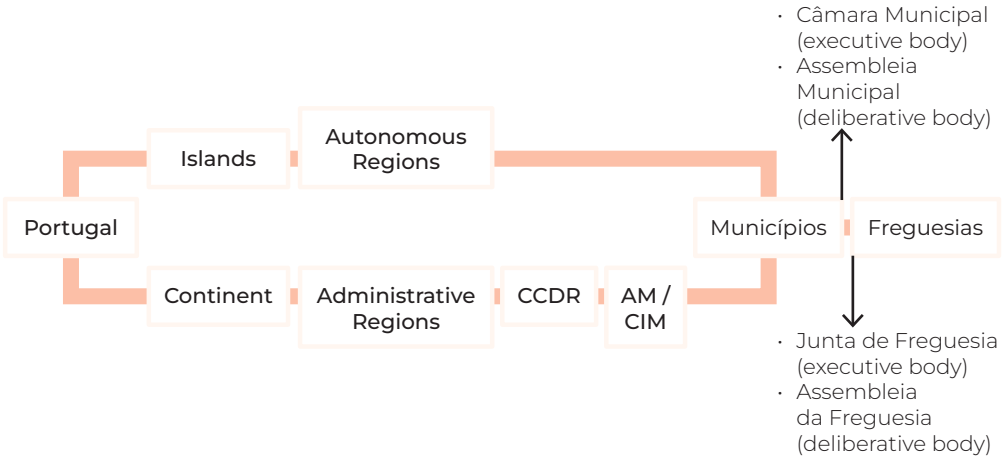


Figure 14. Administrative Division of Portugal
Source: Instituto Nacional de Estatística. (2021, September 8). *Organização geográfica e administrativa*. Mais Transparência: República Portuguesa. https://transparencia.gov.pt/pt/municipios/portugal-e-os-municipios/organizacao-geografica-e-administrativa/

The body recognised by law that is in charge of modifying and fixing these boundaries is called the *Assembleia da República*, while the execution and maintenance of the CAOP are carried out by the *Direção-Geral do Território* (DGT) (DGT, 2023).
According to the delimitation defined by the CAOP2021 Continental Portugal is divided into (Figure 15):

- *Distritos* - administrative and judicial districts (since 1985) (18);
- *Concelhos* - municipalities, the geographical subdivision of the districts, corresponding geographically to the Municípios (308);
- *Freguesias* - civil parishes, the smallest territorial unit in Portugal (3092) (DGT, 2023).

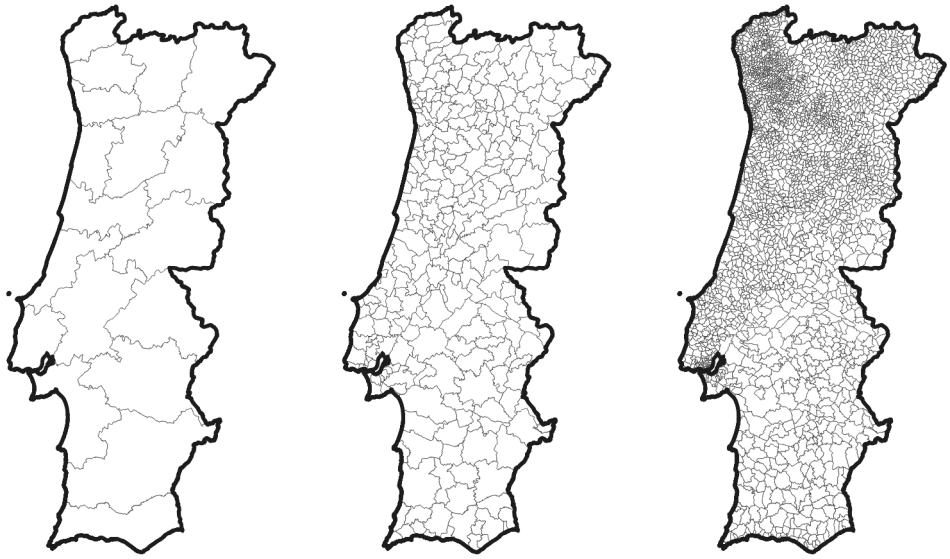


Figure 15. Administrative Division of mainland Portugal according to CAOP22
Source: Direção-Geral do Território. (2023, February 3). *Carta Administrativa Oficial de Portugal*. Direção-Geral Do Território. https://www.dgterritorio.gov.pt/cartografia/cartografia-tematica/caop

3.2.3 Urban mobility planning and management tools in Portugal

The main strategies, plans and urban mobility planning and management documents adopted in Portugal in the last decade have been summarised in Figure 16. They will be analysed in more detail in the following sections, dividing them into national, regional and municipal levels.

In Portugal, the SUMP tool has been translated into a national strategy called *Pacote da Mobilidade*, elaborated in 2011 by the Instituto da Mobilidade e dos Transportes (IMT) (Eltis, 2019; IMT, 2012). This strategy consists of several documents:

- *Diretrizes Nacionais para a Mobilidade* - national guidelines for mobility;
- *Guia PMT* – a guide for the elaboration of Mobility and Transport Plans;
- *Guia PME* – a guide for the elaboration of Mobility Plans for Companies and Poles;
- *Guia PMOT* – a guide for the elaboration of Accessibility, Mobility and Transport Plans in municipal spatial plans (PDM, PU AND PP);
- Technical and thematic brochures on sustainable mobility;
- Guidelines for Urban Logistics (Eltis, 2019; IMT, 2012).

The Portuguese *Plano de Mobilidade e Transportes* (PMT) therefore corresponds to the SUMPs of the European directives and the measures of this plan cover the topics of accessibility, interfaces, road safety, active mobility, urban logistics, land use, quality of urban life, etc. (IMT, 2015). PMT can be declined at a regional, inter-municipal, metropolitan or municipal scale.

According to the *Programa Operacional Regional* (POR) 2014-2020, stemming from the Portugal-EU 2020 Partnership Agreement (Portugal 2020), urban authorities must have a *Plano Estratégico de Desenvolvimento Urbano* (PEDU) approved by the Managing Authority (Lisboa 2020, 2015).

The *PEDU* is the programming tool that supports contracting with urban/municipal authorities and includes 3 action plans to define investment priorities (Câmara Municipal de Lisboa, 2017d):

- *PAMUS* - Action Plan for Sustainable Urban Mobility, defined at NUTS III level;
- *PAICD* - Integrated Action Plan for Disadvantaged Communities;
- *PARU* - Action Plan for Urban Regeneration (Câmara Municipal de Lisboa, 2017d).

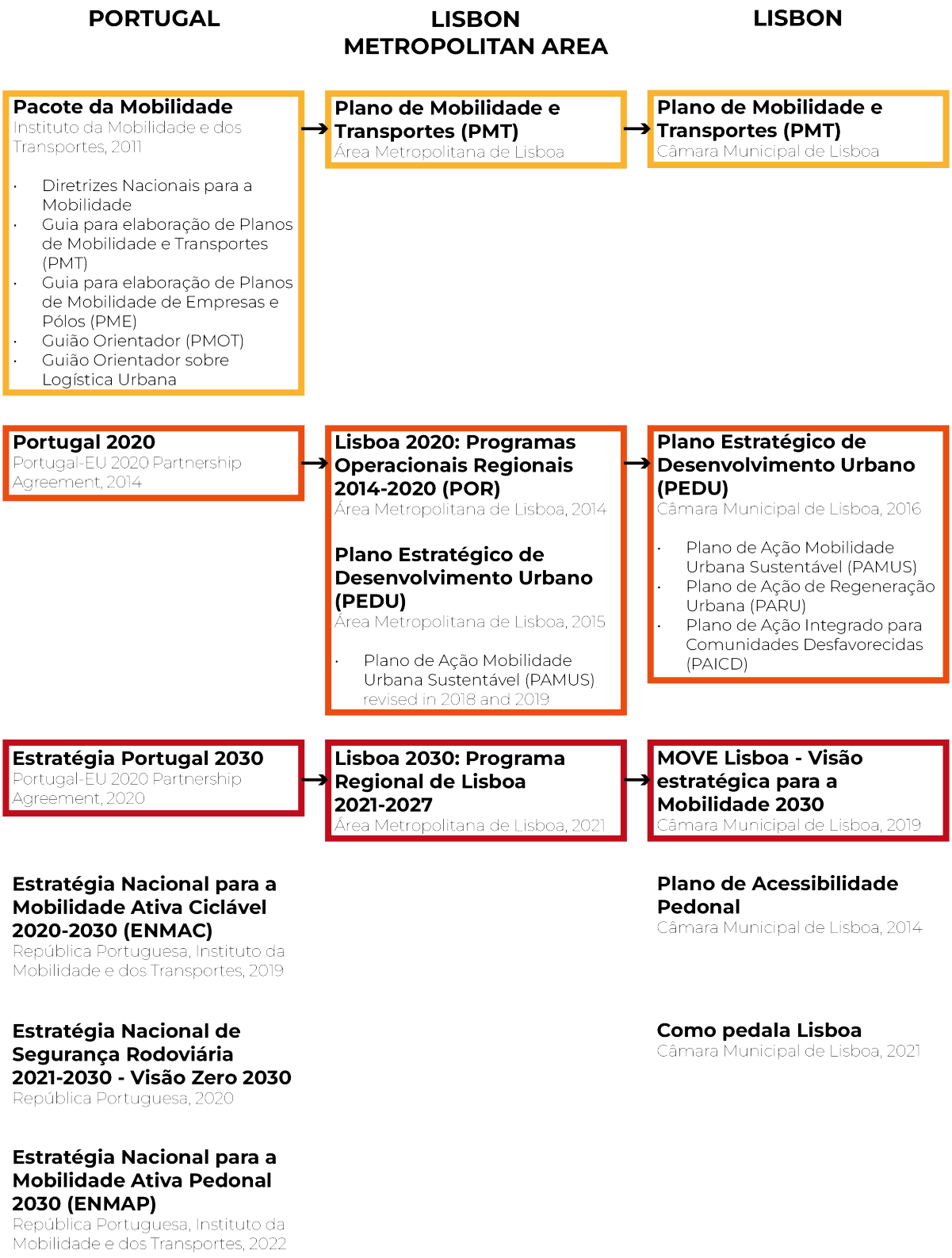


Figure 16. Main urban mobility planning and management policies at different scales in Portugal

The Portugal 2020 strategy was renewed in 2020, when the Estratégia Portugal 2030 was approved, financed by the EU to the amount of €23 billion and stemming from the Partnership Agreement signed between Portugal and the EC in 2022. The strategy is based on 4 themes: "(a) better demographic balance, more inclusion and less inequality; (b) digitalisation, innovation and competence as engines of development; (c) climate transition and sustainability of resources; (d) external competitiveness and internal cohesion of the country" (República Portuguesa, 2020).
To incentivise active mobility in 2019, the *Estratégia Nacional para a Mobilidade Ativa Ciclável 2020-2030* (ENMAC) was approved, promoted by the IMT and articulated by a specially established Interministerial Commission (composed of members of the 5 CCDRs). The strategy consists of 51 measures to promote cycling mobility through 3 axes of intervention: "infrastructure and intermodality, training and support, and culture and behaviour" (Presidência do Conselho de Ministros, 2019).
Later, in 2022, the *Estratégia Nacional para a Mobilidade Ativa Pedonal 2030* (ENMAP) was also approved, elaborated by a working group under the supervision of the IMT, to promote pedestrian mobility and decrease the sedentariness index by 2030 (Lisboa Para Pessoas, 2022).
A further instrument, approved in 2020, is the Estratégia Nacional de Segurança Rodoviária 2021-2030 (Visão Zero 2030) to define road safety policies and decrease the number of road accidents República Portuguesa & ANSR, 2023.

3.2.4 Statistical and Administrative Division of the Lisbon Metropolitan Area (AML)

The *Área Metropolitana de Lisboa* is a metropolitan area comprising 18 *municípios* (Figure 17), grouped in the two sub-regions of Greater Lisbon and the Peninsula of Setúbal (at NUTS II level) and 118 *freguesias*. It constitutes an intermediate-level body of the Local Public Administration and has an associative character (AML, 2023).
It is the nation's most populated metropolitan area, at the NUTS III level, with 2,873,618 inhabitants and the second most populous region, at the NUTS II level, after the Northern Region (Pordata, 2022).
Recent decades have witnessed an increase in population in the AML and the emptying of urban centres. This phenomenon

has meant that the spread of residential areas has not coincided with the concentration of work activities, which are significantly present in Lisbon (INE, 2018).
Simultaneously, at the political level, investments were made in transport in favour of car use, resulting in low use of public transport (INE, 2018).

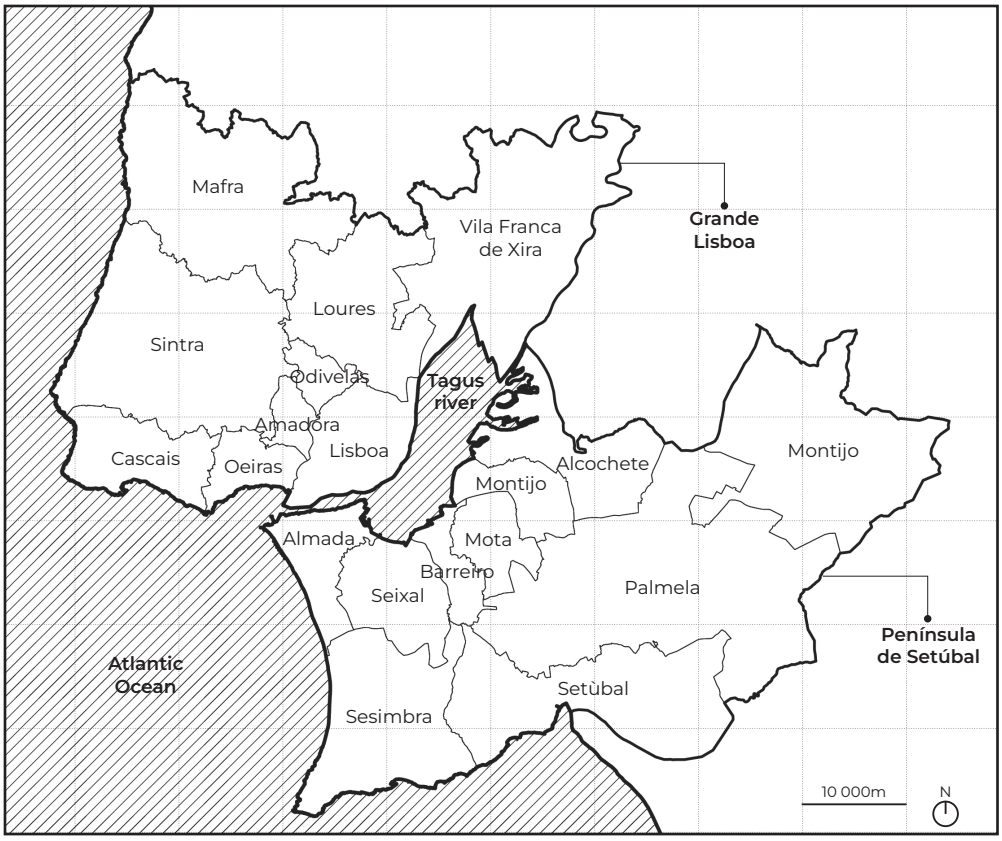


Figure 17. AML's Administrative Division (according to CAOP2022)
Source: Direção-Geral do Território. (2023, February 3). *Carta Administrativa Oficial de Portugal*. Direção-Geral Do Território. https://www.dgterritorio.gov.pt/cartografia/cartografia-tematica/caop

3.2.5 Analysis of AML's urban mobility

To analyse the phenomena concerning urban mobility and find strategies to implement in the AML, several studies have been produced over the last decade.
In 2017, the survey on mobility *Inquérito à Mobilidade nas Áreas Metropolitanas do Porto e de Lisboa* (IMOB) 2017 was produced by the Instituto Nacional de Estatística (INE, 2018). The purpose of the survey was to establish how the population moves daily, the reasons for transport choices, distances travelled, time spent and costs incurred. The results show that the mobile population in AML is 80.4% of the total (aged between 6 and 84 years); that

the car is the predominantly used means, with a value of 58.9%, while the use of public transport amounts to 15.8% (INE, 2018).
In 2021, the study *Rede ciclável metropolitana - Estudo, modelação e ferramenta de apoio ao planeamento e decisão*, developed by *Transportes Metropolitanos de Lisboa* (TML) and *Instituto Superior Técnico* (IST), was published to contribute to the elaboration of a plan for active cycling in AML and to provide a useful tool for the elaboration of the Sustainable Urban Mobility Plan in the future (TML, 2022).
In the same year, TML carried out another study useful for the elaboration of the SUMP, on the evolution of logistics in the AML, to learn about the dynamics of logistics systems and find solutions, particularly for the Setúbal Peninsula (TML & IST, 2021).

3.2.6 AML urban mobility planning and management tools

The *Plano de Ação de Mobilidade Urbana Sustentável da Área Metropolitana de Lisboa* (PAMUS) is a strategic document elaborated in agreement with the PORLisboa 2020 (2015), to frame the financial support needed by the municipalities of the AML, or by the AML itself, regarding decarbonisation and sustainable urban mobility policies (Área Metropolitana de Lisboa, 2019).
It is structured around six axes of intervention:

- Adapt the public transport offer to the mobility needs of the population;
- Strengthen the intermodality of the transport system;
- Strengthen the connectivity of the metropolitan road network and rail modernisation;
- Strengthening the share of soft modes;
- Implement mobility management measures;
- Improving the performance of the logistics system (Área Metropolitana de Lisboa, 2019).

The PAMUS underwent two proposed changes, approved in 2018 and 2019. The most significant change was the introduction of a new pricing system valid for all AML operators and transport tickets, called the Navegante pass, and the development of an Integrated Platform for Ticketing Systems and Intelligent Transport Services (Conselho Metropolitano de Lisboa, 2019). The Navegante pass has reduced public transport costs, allowing travel at 30€ monthly within each AML município and 40€ monthly between all AML municípios (Conselho Metropolitano de Lisboa, 2019).

3.2.7 Statistical and Administrative Division of the City of Lisbon

The city of Lisbon, the capital of Portugal, overlooks the Tagus River, which connects the two banks of the Metropolitan Area via the 25 de Abril Bridge and the Vasco da Gama Bridge (Oliveira & Pinho, 2010). It stands on hilly terrain, with altitudes ranging from 6 to 226 m (Câmara Municipal de Lisboa 2023) and has a temperate climate.

The city currently has a population of 545'923 inhabitants over an area of 100.03 km², with an upward trend until 1981, when it reached approximately 800'000 inhabitants, and a subsequent phase of decline. In AML, however, the opposite trend is observed, with a peak of 2'800'000 residents in 2011 (INE, 2022).

The territory is administratively divided into 24 *freguesias*, which in turn are grouped into five *Zonas* or *Unidades de Intervenção Territorial* (UIT) (Figure 18). Each *freguesia* is governed by a *Junta de Freguesia*, an executive body elected by the members of the *Assembleia de Freguesia*, a deliberative body, itself elected directly by the citizens registered in its territory (DGT, 2023).

In 2012, the city was reorganised at the administrative level, in response to the need to modernise and adapt the model of government, according to the principles of administrative decentralisation and subsidiarity (Procuradoria-Geral Distrital de Lisboa, 2012). The subdivision of the territorial area provided new competencies and financial resources for the *freguesias*, to make them larger and more balanced than in the past. Until 2012, the territory was divided into 53 parishes grouped into 4 *Bairros Administrativos* (Procuradoria-Geral Distrital de Lisboa, 2012).

On average, a freguesia is composed of 22'747 residents per 4.17 km² of the area and the resident population is not equally distributed over the whole territory, but there are some areas with higher density (e.g. Arroios, Campo de Ourique, Areeiro and Penha de Franca) and others with lower density (e.g. Belém and Alcântara) (INE, 2022).

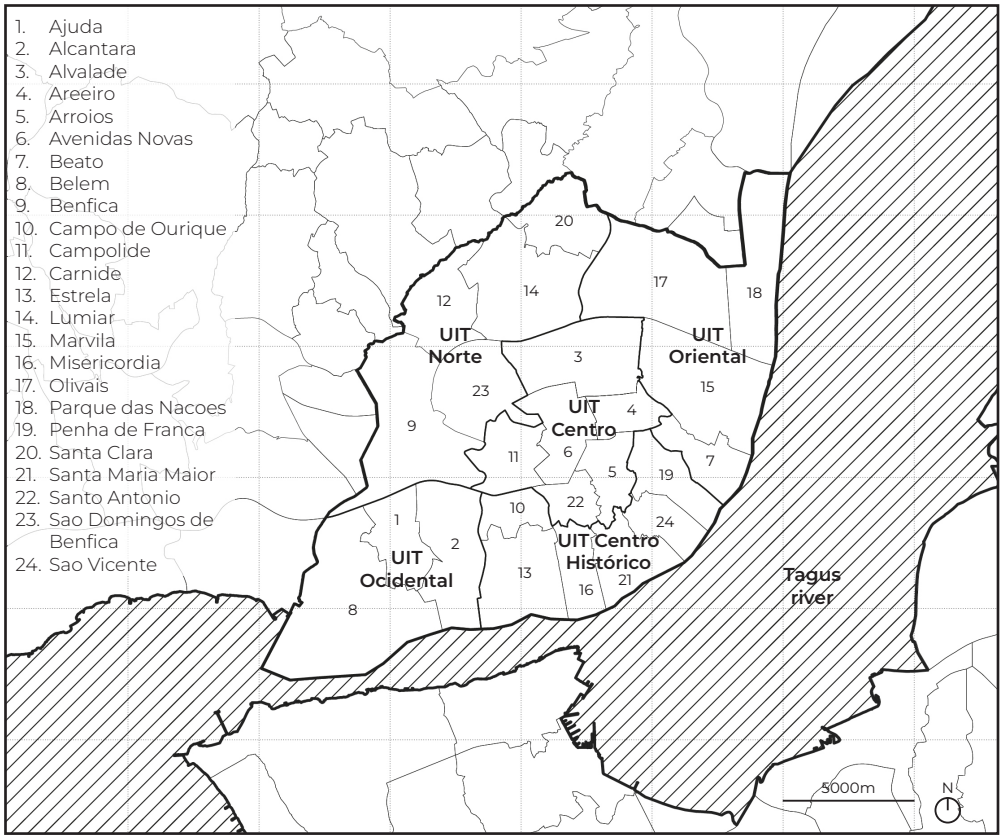


Figure 18. Lisbon's Administrative Division (according to CAOP2022)
Source: Direção-Geral do Território. (2023, February 3). *Carta Administrativa Oficial de Portugal*. Direção-Geral Do Território. https://www.dgterritorio.gov.pt/cartografia/cartografia-tematica/caop

3.2.8 Analysis of Lisbon's urban mobility

The "*IMOB 2017*" survey on mobility in the metropolitan areas of Porto and Lisbon has brought some data to light. The mobile population resident in Lisbon is 80.6% of the total population, a value similar to that of AML (INE, 2018). The most commonly used mode of transport in Lisbon is the car (45.1%), although this percentage is lower than in the AML; on the other hand, the percentage of residents choosing to walk (29.8%) is higher than in the AML, followed by public transport (21.1%), and finally, the number of people choosing to cycle (0.6%) is very low (Figure 19). Journeys are made 63.4% within the Lisbon município, and 36.6% between different municípios. Considering Lisbon as the origin of trips, the destinations where most trips are made are Oeiras, Amadora and Loures. On the contrary, considering Lisbon as the destination of trips, the origins with the greatest flows turn out to be Amadora, Sintra and Loures (INE, 2018).

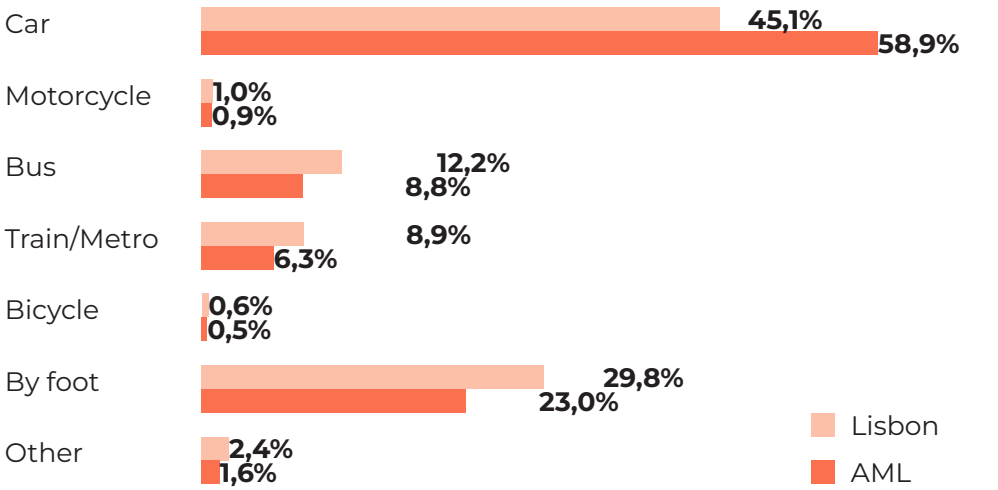


Figure 19. Distribution of the number of trips according to the main means of transport
Source: Instituto Nacional de Estatística. (2018). Mobilidade e funcionalidade do território nas Áreas Metropolitanas do Porto e de Lisboa : 2017. In *Instituto Nacional de Estatística* (ISBN 978-989-25-0478-0). https://www.ine.pt/xurl/pub/349495406

3.2.9 Lisbon urban mobility planning and management tools

In Lisbon, mobility and spatial planning policies were first introduced in 2012, with the *Plano Diretor Municipal* (PDM), while the first study concerning mobility "*Lisboa: o desafio da mobilidade*" dates back to 2005 (Câmara Municipal de Lisboa, 2020a).
The body in charge of mobility planning in Lisbon is the *Câmara Municipal de Lisboa* (CML), and it acts as an intermediary between municipal services, Carris (the company that manages Lisbon's PT), EMEL (the company that manages Lisbon's mobility and parking) and the Municipal Police. The CML also communicates with the Portuguese Republic's government, the Lisbon Metropolitan Area, other local governments, transportation providers, and mobility service providers (Câmara Municipal de Lisboa, 2020a).
In 2019, the Municipality of Lisbon drew up a document called "Move Lisboa - Strategic Vision for Mobility 2030" to reduce the percentage of trips within the city that involve private vehicles to no more than 34% (Câmara Municipal de Lisboa, 2020a).
The vision for mobility in Lisbon - MOVE Lisboa - is based on six pillars: more integration, more trust, more connectivity, more accessibility, more innovation and more responsibility.
These pillars translate into a series of measures: "increasing the attractiveness of public transport, adding new mobility services to the transportation network, reducing the access of private cars

to the centre and surrounding hills, putting into action safety-enhancing measures for the transportation system as outlined in the Municipal Road Safety Plan, implementing a strategy to accelerate the adoption of electric mobility, upgrading public space and the pedestrian network, improving mobility to and from school, expand the network of bicycle lanes, increase the resident population, promote the use of the Tagus river as a river mobility infrastructure, continue to build out park-and-ride facilities around PT interfaces that are off-centre, find new employment poles around PT interfaces, take on new forms of work (such as smart-working), defend the urgency of metropolitan investments in heavy mobility, and strengthen the metropolitan-wide coordination of mobility systems" (Câmara Municipal de Lisboa, 2020a).

MOVE proposes a Mobility Planning consisting of a multimodal and intermodal transport system, composed of 5 networks: "Pedestrian, Public Transport, Road, Bicycle and Interfaces" and 5 services "Parking, Shared Services, Urban Logistics, Additional Mobility and Tourism" that dialogue with each other (Câmara Municipal de Lisboa, 2020a). Mobility Management is instead divided into 5 transversal axes: "Management, Control and Optimisation of Resources; Information, Promotion, Awareness-raising and Public Participation; Financing; Regulation; Monitoring, Evaluation and Review" (Câmara Municipal de Lisboa, 2020a).

Beyond this strategic document, another planning tool is the *Grandes Opções do Plano 2023-2027*, which includes the Annual Economic Plan and the Multiannual Investment Plan of the City of Lisbon for the next 4 years. The Plan aims to make the city participatory, sustainable, culturally, economically and innovatively attractive, supportive, caring for citizens' health and education, resilient and safe (Câmara Municipal de Lisboa, 2022). In particular, sustainable means strategies that focus on environmental conservation, neighbourhood planning, diversification of mobility and renewal of public space (Câmara Municipal de Lisboa, 2022).

The aspect of urban mobility is closely interconnected with that of accessibility and thus neighbourhood planning. Among the planned actions, the development of a practical application of the theoretical model of the 15-Minute City is promoted, to build a model of proximity urban functions (commerce, green and leisure spaces, education, culture and health) and an attractive and safe pedestrian network for the city's neighbourhoods (Câmara Municipal de Lisboa, 2022).

Two documents deal specifically with pedestrian and cycling mobility: *Plano de Acessibilidade Pedonal (2013 – 2017)* and *Como pedala Lisboa* (Câmara Municipal de Lisboa, 2013; Câmara Municipal de Lisboa, 2021).

The *Plano de Acessibilidade Pedonal* aims to define a strategy for Lisbon's accessibility from 2014 to 2017, to prevent the creation of further architectural barriers, adapt existing spaces and buildings, and create a city "for all", including the community in the design of solutions. The Plan is divided into five operational phases: public roads, municipal facilities, articulation with the public transport network, supervision of private individuals and cross-cutting challenges (Câmara Municipal de Lisboa, 2013).

The strategy is divided into a first phase of operational diagnosis, to identify challenges and critical points, a second phase of outlining a policy to address these challenges, and a third phase of concrete actions to implement the planned policy (Câmara Municipal de Lisboa, 2013).

Lisbon's topography and historical heritage constitute constraints for improving pedestrian accessibility, so it is necessary to promote an integrated macroscale (integrating the different infrastructure networks) and microscale vision.

Further problems are given by the numerous stakeholders in the city, which make coordination between the different entities essential; by the multiple demands caused by the extensive road network and the considerable volume of urban operations; by the excess of cars, which highlight how public space has been created in favour of vehicular traffic and there is instead a need to re-establish a balance between all users (Câmara Municipal de Lisboa, 2013).

The Plan-Process has a strategic character and is composed of continuous work that may involve modifications in progress, evaluating methods and tools used and involving the population in the decision-making, monitoring and implementation process (Câmara Municipal De Lisboa, 2013).

On the other hand, The document *Como pedala Lisboa* collects useful information and data on the use of the bicycle within the city by the population, the costs and benefits of its use, the existing infrastructure and existing projects (Câmara Municipal de Lisboa, 2021).

Since 2001, when the first bicycle lanes were built for recreational purposes, Lisbon has developed an increasingly extensive network of bicycle lanes. In 2017, the first utilitarian cycle track was inaugurated, connecting areas with services and

commercial activities, and has become one of the most used in the city (Câmara Municipal de Lisboa, 2021).

The expansion of cycling infrastructure and the introduction of the GIRA public shared bicycle system has contributed to the increase in bicycle use in the city, monitored through observational counts. From 2017 to 2020, there has been a 138% growth in bicycle use. In recent years, the bicycle network has grown significantly: from about 90 km in 2017 to about 150 km in 2020, intending to reach 200 km of bicycle lanes by 2021 (out of a total of 1700 km of roads) (Câmara Municipal de Lisboa, 2021). This has connected several neighbourhoods and encouraged more and more people to use bicycles as a means of transport (Câmara Municipal de Lisboa, 2021).

In addition to conventional bicycles, electric bicycles account for a significant percentage of private bicycles on the road, partly due to the city's orographic characteristics. Although the city is located on hilly terrain, 73% of the roads have a gradient of 5% or less (Câmara Municipal de Lisboa, 2021).

Lisbon has also implemented several initiatives to promote cycling among students and has invested in the creation of bicycle parking facilities to facilitate and encourage safe parking. Surface parking spaces have been installed and covered and protected parking spaces are being developed. These parking facilities help to improve safety and accessibility for cyclists (Câmara Municipal de Lisboa, 2021).

Figure 20 shows the existing cycle lanes, GIRA service and conventional bicycle parking points.

The Lisbon Chamber of Commerce recently integrated the GIRA bike-sharing service for those with an active Navegante monthly pass, making it free for residents (Lisboa Para Pessoas, 2023).

Currently, the service is free for students up to 24 years of age and those over-65s, and there is a discount subscription for the other residents, but the idea is to extend it to everyone soon (Lisboa Para Pessoas, 2023).

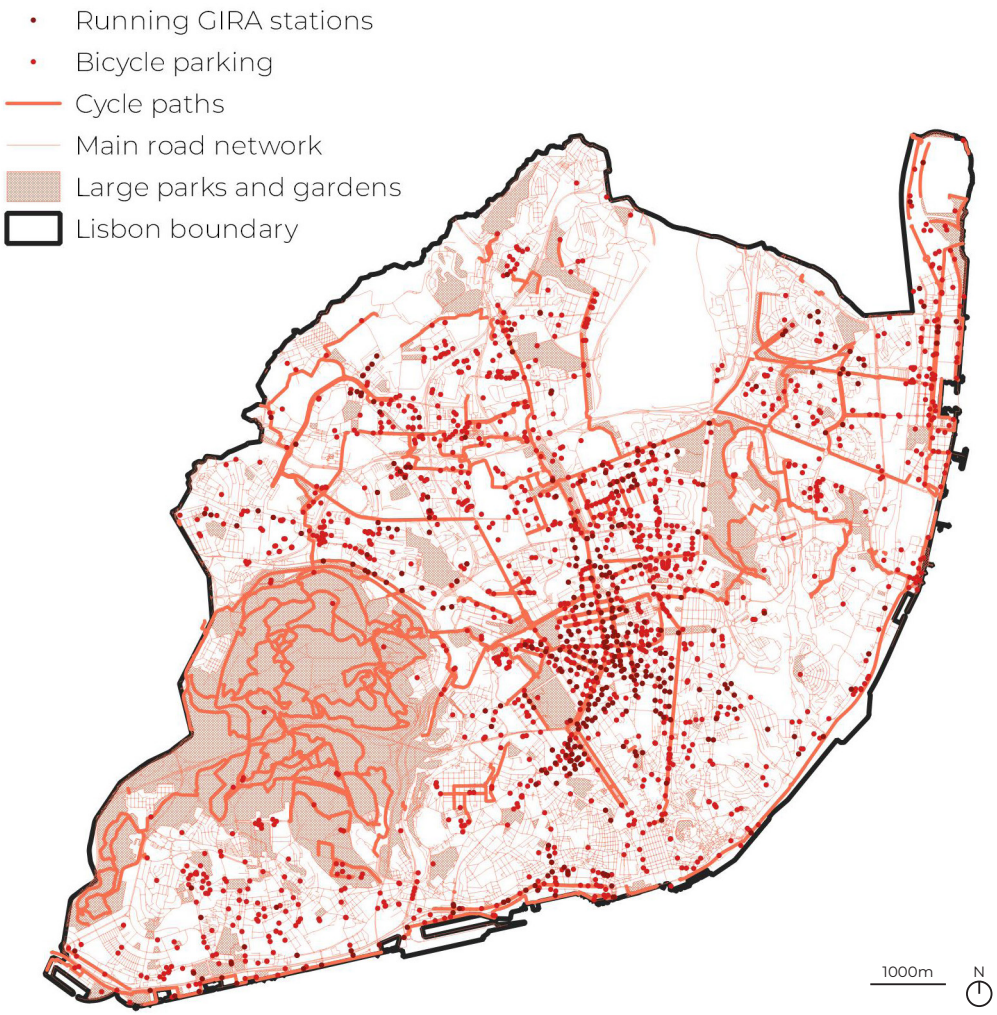


Figure 20. Cycle paths and parking spots in Lisbon
Source: Câmara Municipal Lisboa. (2023). *Geodados*. https://geodados-cml.hub.arcgis.com/

There are also some other documents produced by the Câmara Municipal De Lisboa that have not been mentioned in the previous chapters, and which deal with issues of urban planning and mobility in the city, adaptation to climate change, etc.
They are listed below for information purposes.

- *Uma Praça em cada Bairro* (2014-2020): promoted by the CML in cooperation with the 24 juntas de freguesia (the administrative bodies of the neighbourhoods). The programme aims to redevelop public space through reversible solutions, allowing solutions to be tested before they become permanent. The objective is to enhance Lisbon's identity as a city of neighbourhoods, promoting a mix of residence, employment and commercial activities in all neighbourhoods, identifying meeting and sociability points that unite Lisbon's different communities (CML, 2014).

- *Pavimentar Lisboa 2015-2020*: promoted by the CML, the plan aims to improve road safety and comfort and optimise urban mobility by paving and transforming 100 km of streets and pavements. In particular, the needs of the most fragile people in the use of these environments are taken into account (CML, 2020a).
- *Estratégia Municipal de Adaptação às Alterações Climáticas* (EMAAC) (2017): the strategy promoted by CML is developed around national objectives, including improving the level of knowledge on climate change, adopting adaptation and mitigation measures through specific targets, and strengthening partnerships between public and private entities (CML, 2020a).
- *Plano de Ação de Energia Sustentável e Clima* (PAESC) (2018): the plan developed by the CML, Lisboa E-Nova (Lisbon Energy and Environment Agency) and Instituto de Ciências Sociais (from Universidade de Lisboa), aims to identify and assess local challenges and priorities regarding climate and energy issues, monitor progress, and inform policymakers and the public (CML, 2020a).

3.2.10 Conclusions on the policies analysed

In conclusion, the urban mobility policies adopted by the Portuguese government and its administrations promote healthy behaviours, such as physical activity, the adoption of a healthy environment that aims to reduce air and noise pollution, and the reduction of road accidents through the encouragement of active mobility and renewal of infrastructure. Despite the policies adopted and the fact that the percentage of journeys made on foot or by bicycle is increasing in the Lisbon municipality, especially following the Covid-19 pandemic, the mode of transport most used by the population remains the car (CML, 2021; ine, 2018).
Among the policies introduced, the most effective in reducing the modal share travelling by car appears to be the modification to the PAMUS in 2019. It consists of the introduction of a new pricing system valid for all operators and transport tickets in the Lisbon Metropolitan Area (Navegante pass), which has reduced the cost of public transport and increased its use (AML, 2019).
Another effective strategy is the expansion of the bicycle infrastructure and the introduction of the GIRA public shared bicycle system, which have been done in the last 3 years,

contributing to the increase of bicycle use in the city as a means of travel (CML, 2021).

However, the city needs strategic planning of the transport network and urban mobility management, through the drafting of the SUMP, following the needs of citizens, EC directives and the studies and plans drawn up so far. The drafting of the plan is up to the Câmara Municipal De Lisboa, in cooperation with all the bodies involved (AML, EMEL, Carris, etc.), to promote soft, shared and multimodal mobility, according to a logic of ecological transition of the city (CML, 2020a).

It is remarkable that, in addition to policies to improve mobility, the Lisboa municipality wants to develop better accessibility, through the redevelopment of public spaces (CML, 2014) and measures to encourage proximity services through the application of the 15-Minute City concept (CML, 2022).

It might be interesting to evaluate the social, economic and health impacts following the implementation of such policies, as suggested in the study proposed by Lozzi & Monachino (2021) and compare the data obtained with those of other European capitals.

Chapter 4
Lisbon accessibility analysis

4.1 Methodology

To examine the pedestrian and bicycle accessibility of the city of Lisbon, it was used a method elaborated by Professor David Vale (Associate Professor at Lisbon School of Architecture, University of Lisbon) and André Lopes (Postdoctoral Researcher at the University of Lisbon), learnt during the course "Sustainable Urban Mobility" of the Master of Science in Architecture course at the University of Lisbon.
The methodology used to obtain and analyse the data consists of five main steps:

1. Defining a partition of the city that corresponds to the Origins of the trips that the resident population makes to access different services in the territory;
2. Define Destinations, a set of services present in the area at the district level;
3. Define the Pedestrian and Bicycle Network of the Lisbon metropolitan area;
4. Define an Origin-Destination Matrix, which considers the shortest paths;
5. Define the accessibility of services about the census tracts, at the pedestrian and bicycle level, in 5-, 10- and 15-minute time slots.

The data were obtained (except for the first phase) from OpenStreetMap, through 4 different codes written with the Python programming language by professors D. Vale and A. Lopes, modifying the parameters of the case study; the results were then analysed using the QGIS Geographic Information System and the Microsoft Excel programme.

4.1.1 Definition of the Origins

The first part of the process is to define the areas of the city whose centroids correspond to the Origins of the trips citizens make to access different services.
As database was used the *Base Geográfica de Referenciação de Informação* (BGRI 2021 Lisboa - https://mapas.ine.pt/download/index2011.phtml), a geographical infrastructure derived from

the census carried out in 2021, which subdivides the Portuguese national territory into small areas for statistical purposes and respects the administrative boundaries defined in the CAOP (Caldeira, 2022).

In the specific case of this thesis, the Origins correspond to the centroids of each of the *subsecções estatísticas* (census tract) of the city of Lisbon, as specific data on the resident population concerning housing are not available.

Figure 21 shows the city of Lisbon divided by *subsecções estatísticas*.

The *subsecção estatística* is the basic territorial unit of the BGRI that identifies the smallest homogeneous built-up or non-built-up area within the secção estatística. The *secção estatística* is the territorial unit that corresponds to a continuous area of a single freguesia with an average number of dwellings destined for housing that varies between 550 and 650 (Caldeira, 2022).

Figure 21. Lisbon census tracts
Source: Instituto Nacional de Estatística. (2022, November 23). *Censos - Importação dos principais dados alfanuméricos e geográficos (BGRI e GRID)*. Censos 2021. https://mapas.ine.pt/download/index2021.phtml

The municipality of Lisbon is divided into 2822 *subsecções estatísticas* (figure 15), which have an average area of 35'448.19 m^2, from the smallest of 737 m^2 to the largest of 3'720'783 m^2. The tracts with the largest surface area are mainly located at the riverfront, airport and major parks, and correspond to the areas with the lowest resident population; those with the smallest surface area are mostly located in the historic centre area.
The average number of residents for each tract is 205, with values ranging from 1 to 1619. This excludes tracts with no residents, which are 157.

4.1.2 Definition of the Destinations

To obtain travel Destinations, i.e. the geolocation of services at which citizens perform certain activities, a bounding box covering the Lisbon metropolitan area was first delimited (using the coordinates of the area). Secondly, some services were selected using the Python package OSMnx, which allows downloading geospatial data from OpenStreetMap (OSM - https://www.openstreetmap.org/#map=6/39.602/-7.839), an open geographic database that allows free access to information. This process was implemented using a code written with the Python programming language by Professors David Vale and André Lopes (from the University of Lisbon), modifying some lines according to the categories to be analysed. The distribution of selected services across the territory is illustrated in Figure 22. There are 19 services taken into consideration and they can be grouped into 3 macro-categories (Table 3):

- Education: preschool, 1st cycle schools (6-10 years), 2nd cycle schools (10-12 years), 3rd cycle schools (12-14 years) and secondary schools (15-18 years);
- Health and social services: police stations, post offices, churches, open-air markets, social facilities, health centres (USF), pharmacies, registry offices and banks;
- Entertainment: libraries, theatres, cinemas, green areas and sports facilities.

In the decision-making process to assess which categories of services to investigate, existing literature was used (Abdelfattah & al, 2022; Calafiore et al., 2022; EIT Urban Mobility & Technical University of Munich, 2022; Staricco, 2022;), including services considered essential at the neighbourhood scale and excluding those needed at the city scale. Furthermore, only services available through OpenStreetMap were considered.

Table 3. Number of locations for each of the 19 services considered

Destinations		Destinations		Destinations	
Education		**Health and social services**		**Entertainment**	
Kindergartens	37	Police stations	59	Libraries	75
1° Cycle schools	129	Post offices	49	Theatres	51
2° Cycle schools	59	Churces	209	Cinemas	11
3° Cycle schools	52	Open-air markets	25	Green areas	707
Secondary schools	40	Social facilities	52	Sports facilities	671
		Health centers	41		
		Pharmacies	293		
		Register offices	79		
		Banks	306		

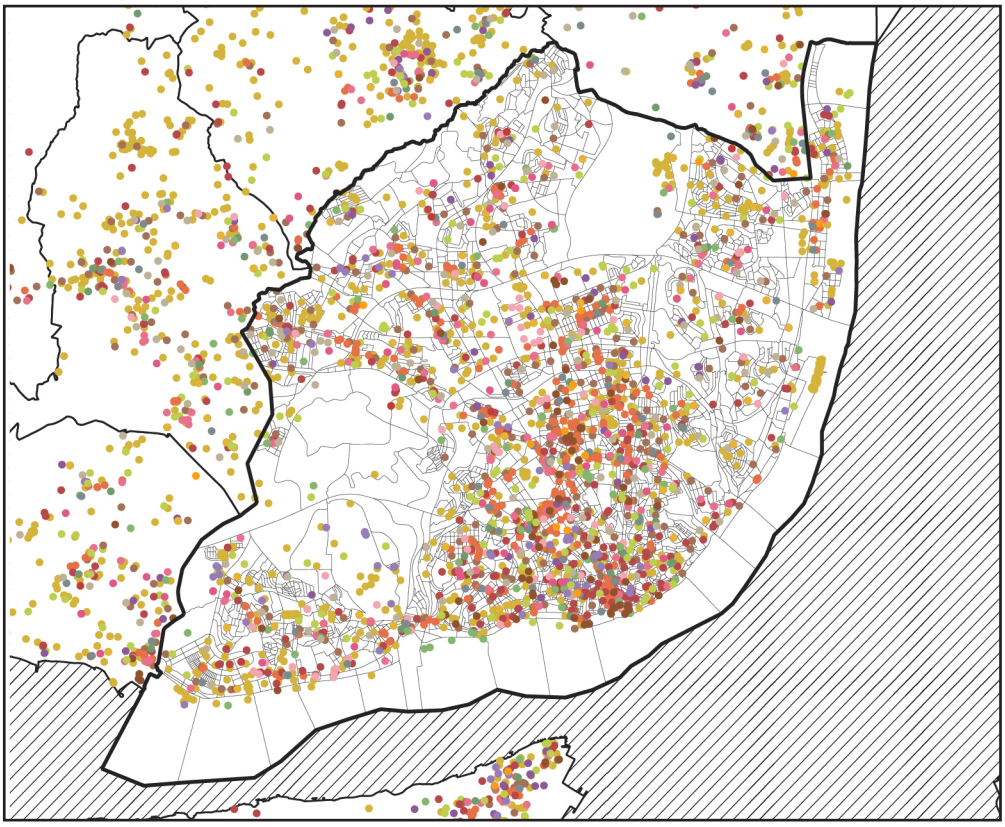


Figure 22. Distribution of selected services across the territory
Source: OpenStreetMap contributors. (2023, March 6). *Map features*. OpenStreetMap Wiki. https://wiki.openstreetmap.org/wiki/Map_features

A more comprehensive approach would have been a participatory one, involving the resident population through questionnaires, meetings or other means. This would have made it possible to define the most relevant activities for the specific context analysed and to assign different weights to the various services.
The number of locations of the 19 services considered varies significantly, from 11 in the case of cinemas to 707 in the case of green areas. In Table 1, only destinations located within the Lisbon perimeter are calculated, but to obtain data on accessibility Origin-Destination, services belonging to the whole Metropolitan Area were taken into account.
Each location was georeferenced as a point indicating the service, corresponding to the centroids of the polygons.

4.1.3 Definition of the AML's Pedestrian and Bicycle Network

The third step was to obtain the Pedestrian and Bicycle Networks of the Lisbon Metropolitan Area so that the fastest route from each Origin to each Destination could be calculated later. They are shown in Figures 23 and 24.
To obtain these networks, another code written with the Python programming language by Professors D. Vale and A. Lopes was modified, using average walking and cycling speed values of 4.8 km/h and 15.2 km/h, respectively; OpenStreetMap was used as a source.
The thesis focuses on active mobility as a mode of travel, but the procedure can also be applied to travel by public transport and car. However, this would require additional data (e.g. traffic data) and would add more complexity; instead, it was deemed sufficient to analyse active travel methods relative to the application of the 15-Minute City theory.

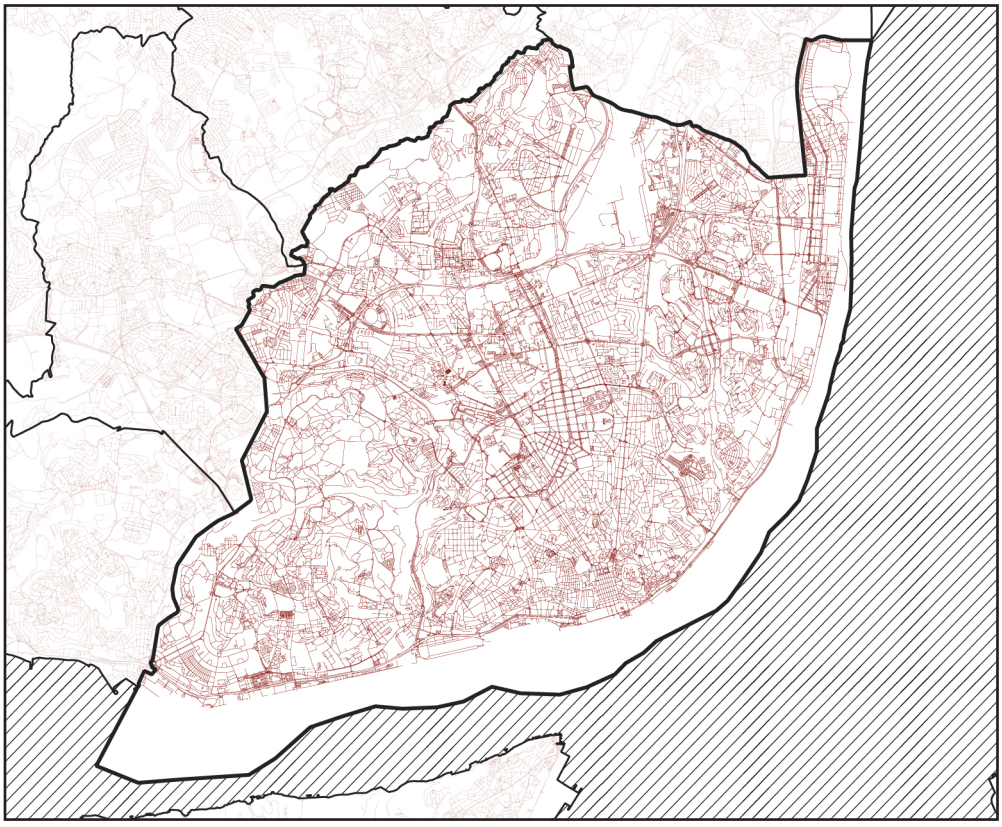


Figure 23. AML Pedestrian Network, focus on Lisbon
Source: OpenStreetMap contributors. (2023, March 6). *Map features*. OpenStreetMap Wiki. https://wiki.openstreetmap.org/wiki/Map_features

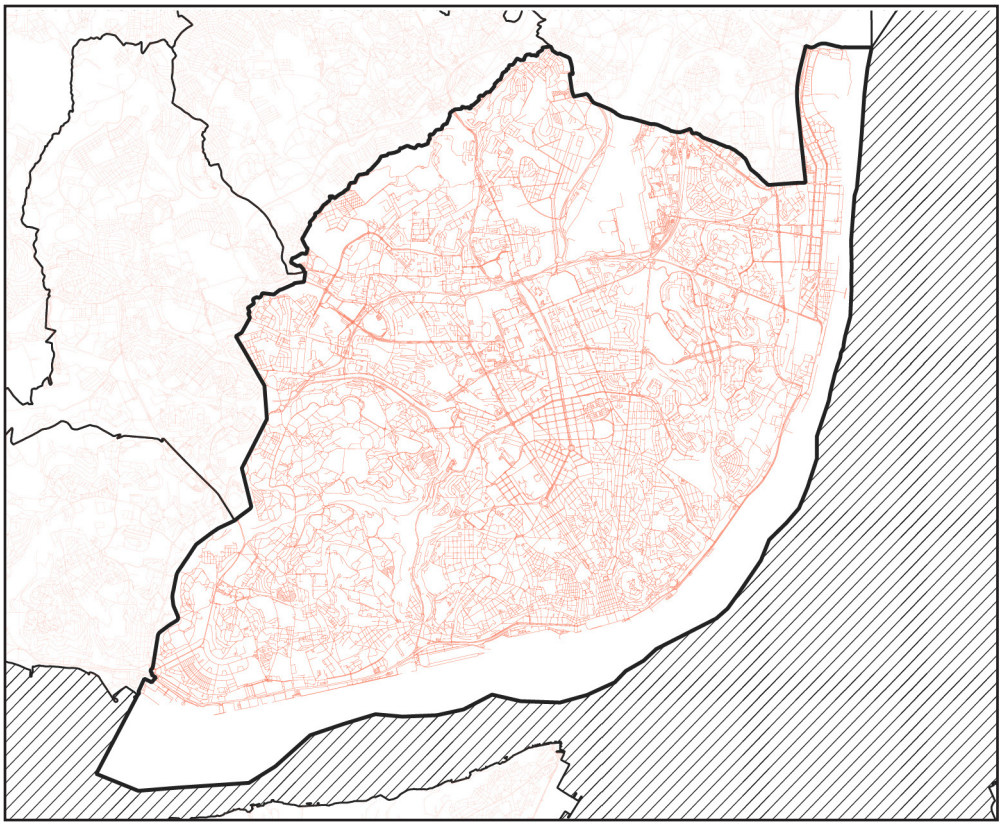


Figure 24. AML Bicycle Network, focus on Lisbon
Source: OpenStreetMap contributors. (2023, March 6). *Map features*. OpenStreetMap Wiki. https://wiki.openstreetmap.org/wiki/Map_features

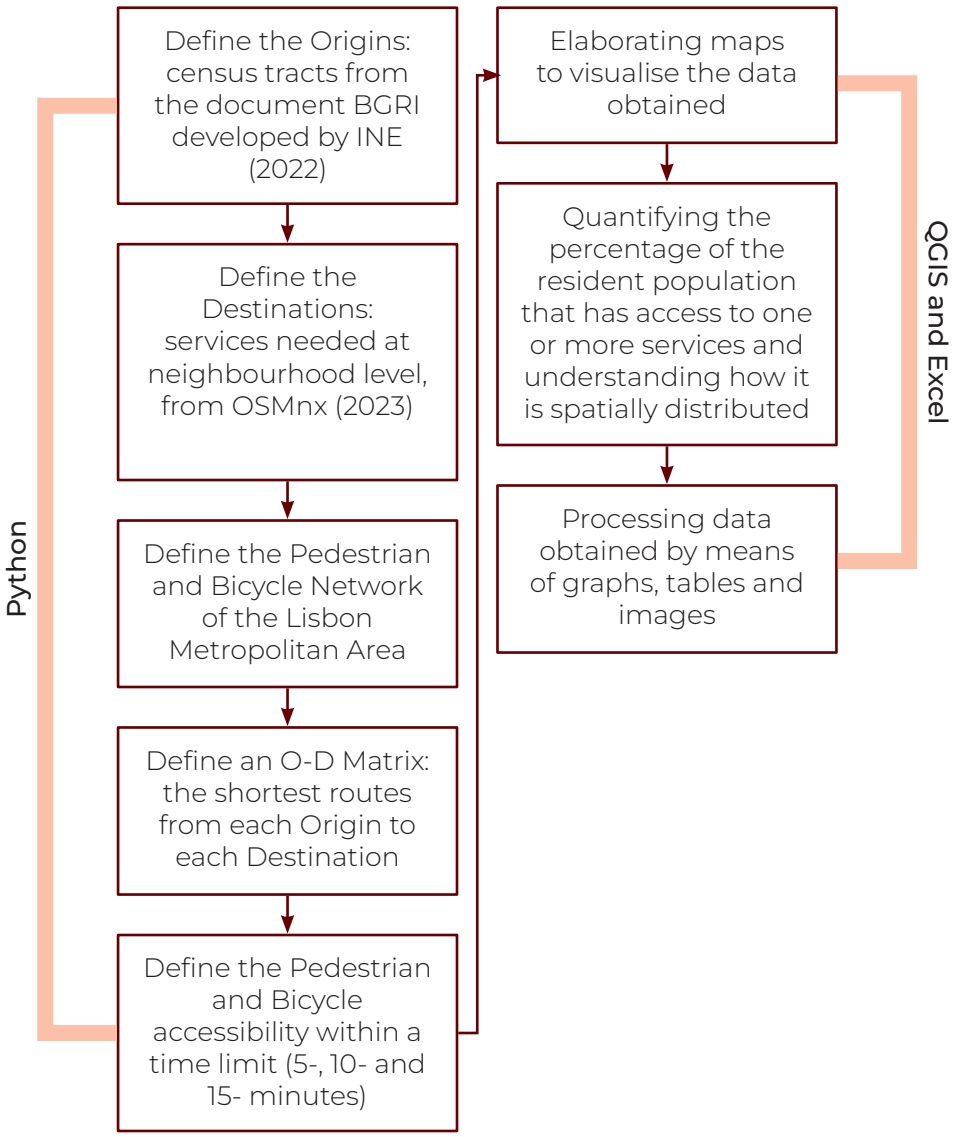
4.1.4 Define an Origin-Destination Matrix

The fourth step involves the creation of an Origin-Destination Matrix, i.e. to go and define the shortest distance from each Origin centroid (census tract) to each Destination centroid (the analysed service), using the cycle and pedestrian road network obtained previously. The process was then repeated for each of the 19 services analysed. Again, a code written by Professors D. Vale and A. Lopes was used and modified to obtain the matrix.
The result obtained consists of an Excel file for each of the 19 services chosen, in which the following data are given: each point of Origin is associated with each point of Destination and the shortest travel time between the two. The previously obtained pedestrian and bicycle network was used to calculate the shortest route.

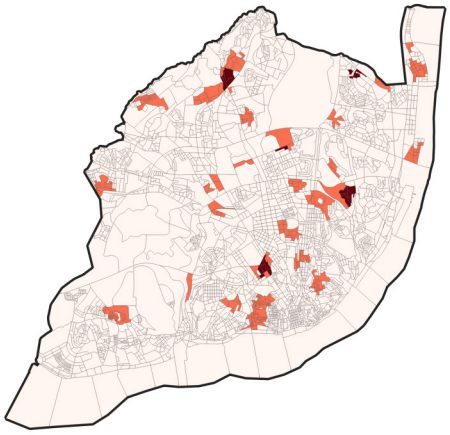
4.1.5 Define the accessibility of services concerning the census tracts

The last step was to calculate the accessibility of the city of Lisbon, using the Matrix obtained in the previous step. For each of the 2 road networks (pedestrian and bicycle), 3-time thresholds were set, 5-, 10- and 15-minutes. The result was the creation of a GeoJSON file (thus containing geographic data), which could be examined using QGIS software. The file indicates, for each census tract of the city of Lisbon, the number of services accessible within the period of 5-, 10- or 15-minutes on foot or by bicycle. This process was repeated for each of the 19 services considered.
Each census tract also presents information on the total number of inhabitants and those by age group, and it was, therefore, possible to calculate the amount of the population that has access to certain services.
The steps of this methodology, which led to results that are analysed in the following section, are summarised in Figure 25. Figures 26 to 44 show the census tracts that have access to a number of service locations within 5-10 or 15 minutes walking or cycling distance, for each of the 19 services analysed.

Figure 25: Summary of steps in the methodology used

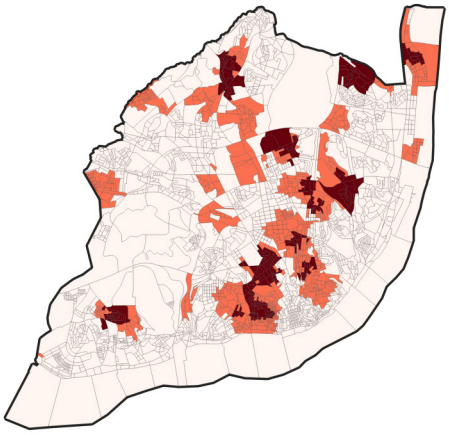


Education | Kindergartens



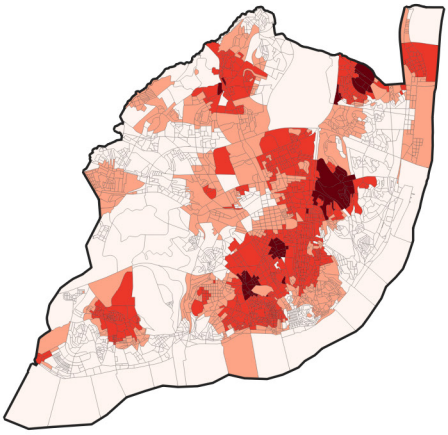
5 minute | Walking

- 0
- 1
- 2 - 3
- Administrative Limit



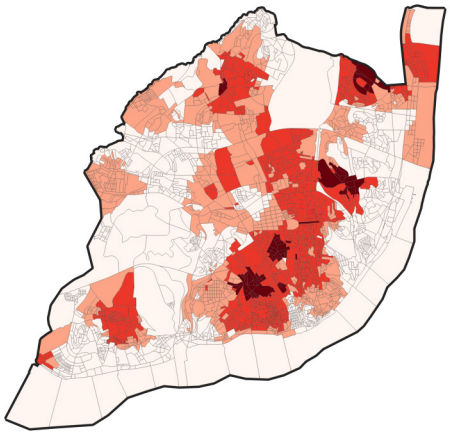
10-minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



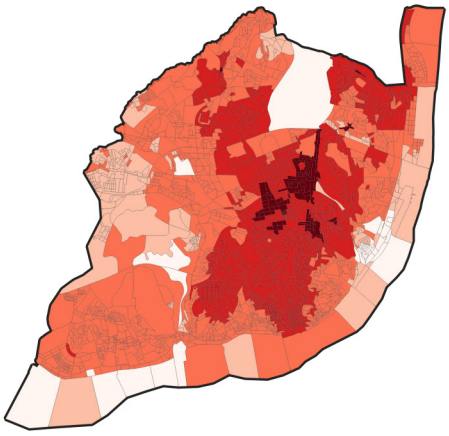
15-minute | Walking

- 0
- 1
- 2 - 3
- 4 - 5
- Administrative Limit



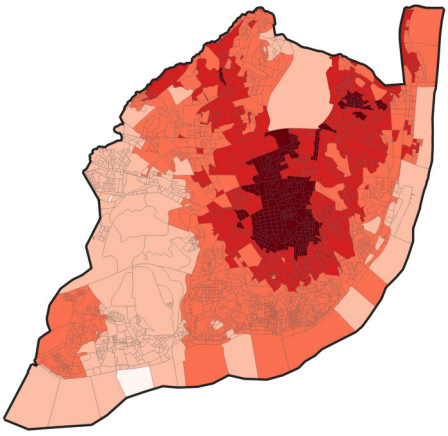
5 minute | Cycling

- 0
- 1
- 2 - 3
- 4 - 5
- Administrative Limit



10-minute | Cycling

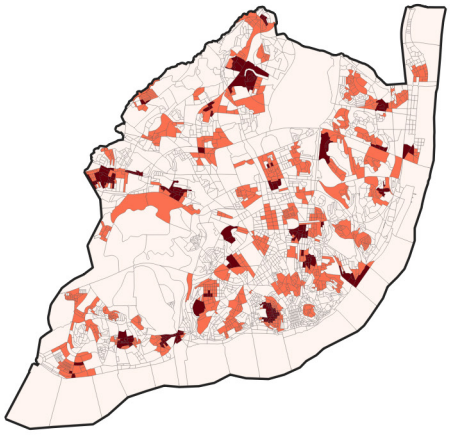
- 0
- 1
- 2 - 5
- 6 - 9
- 10 - 12
- Administrative Limit



15-minute | Cycling

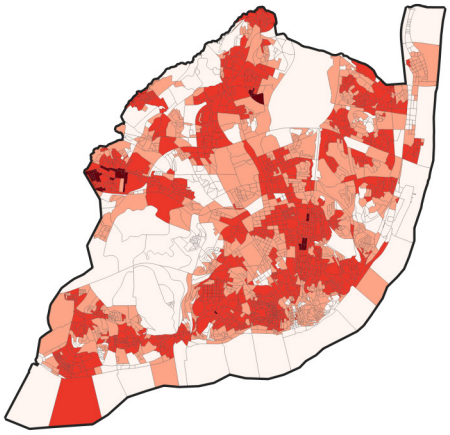
- 1
- 2 - 6
- 7 - 11
- 12 - 16
- 17 - 22
- Administrative Limit

Education | Schools 1° cycle (6-10 y.o.)



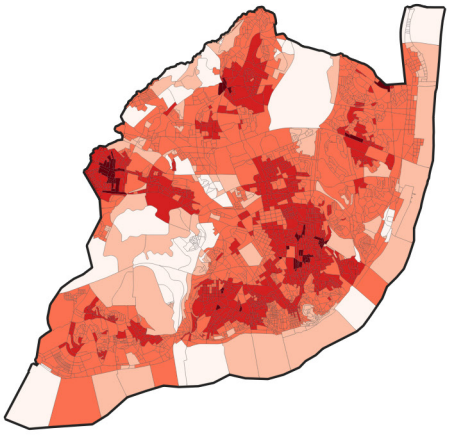
5 minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



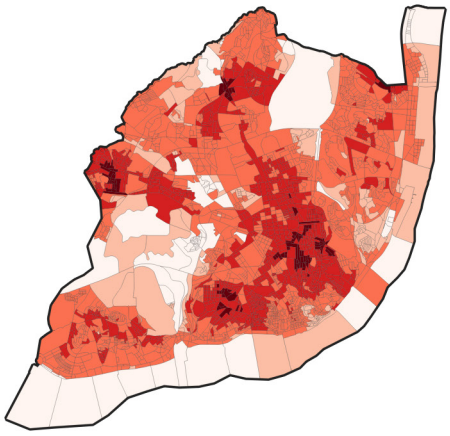
10-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 6
- Administrative Limit



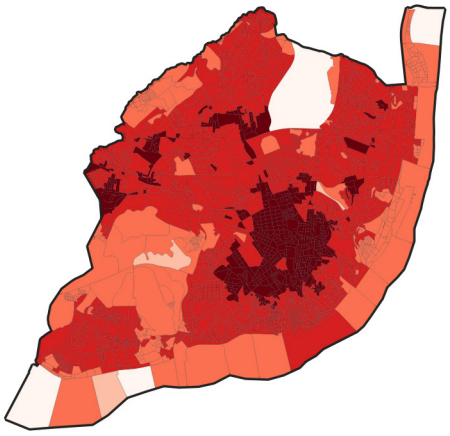
15-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 7
- 8 - 10
- Administrative Limit



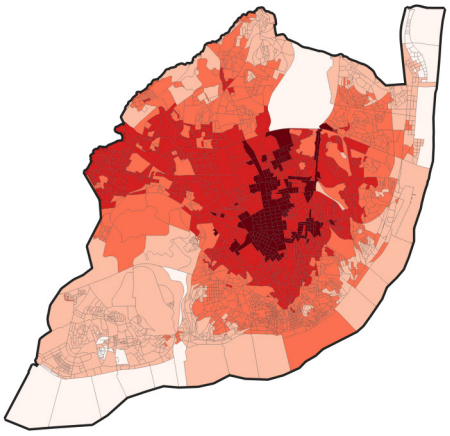
5 minute | Cycling

- 0
- 1
- 2 - 4
- 5 - 7
- 8 - 10
- Administrative Limit



10-minute | Cycling

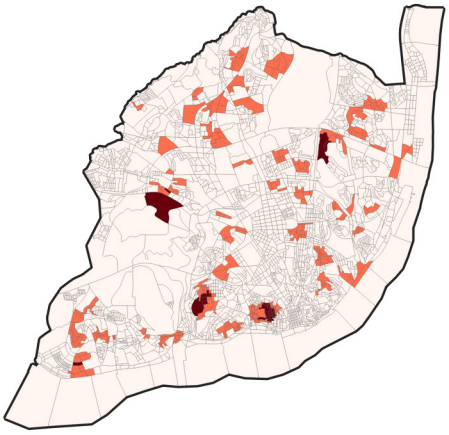
- 0
- 1
- 2 - 10
- 11 - 19
- 20 - 28
- Administrative Limit



15-minute | Cycling

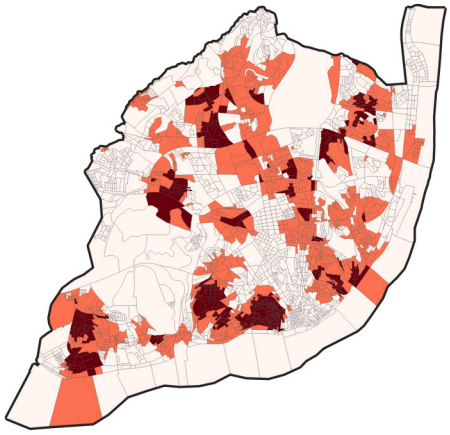
- 6 - 16
- 17 - 26
- 27 - 36
- 37 - 46
- 47 - 56
- Administrative Limit

Education | Schools 2° cycle (10-12 y.o.)



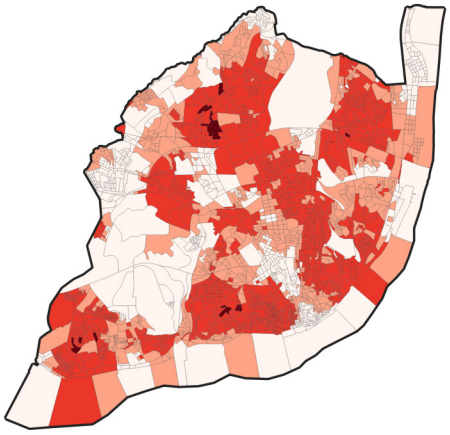
5 minute | Walking

- 0
- 1
- 2 - 3
- Administrative Limit



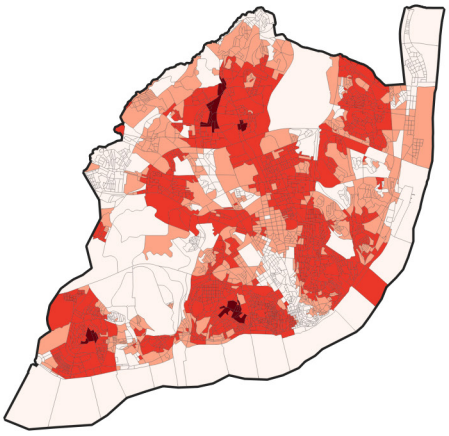
10-minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



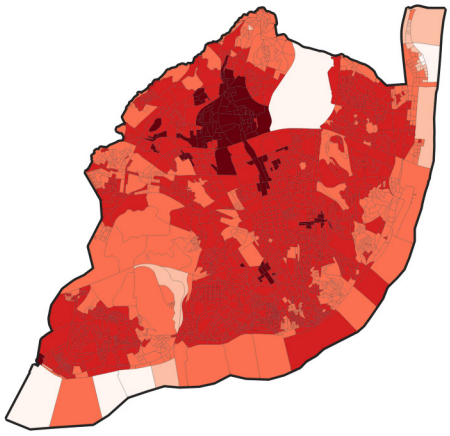
15-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 6
- Administrative Limit



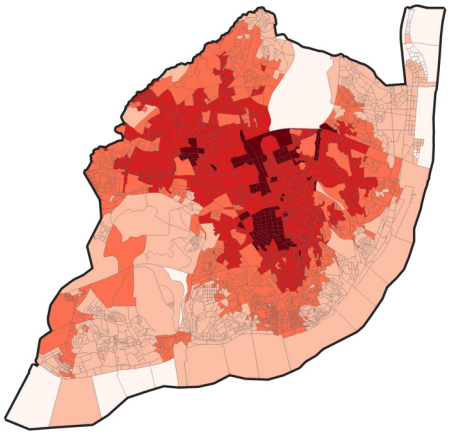
5 minute | Cycling

- 0
- 1
- 2 - 4
- 5 - 6
- Administrative Limit



10-minute | Cycling

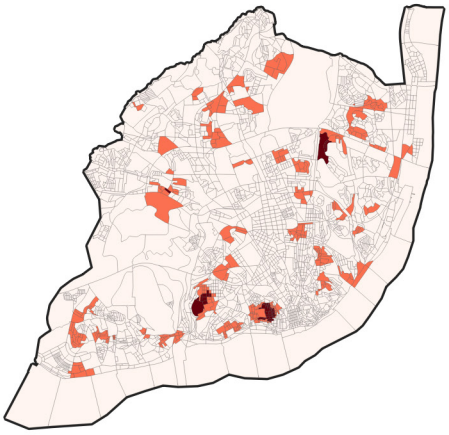
- 0
- 1
- 2 - 5
- 6 - 10
- 11 - 15
- Administrative Limit



15-minute | Cycling

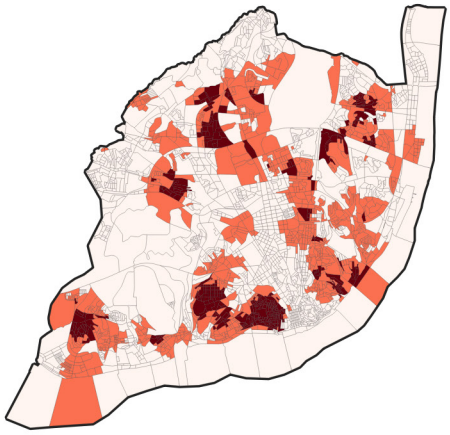
- 3 - 7
- 8 - 12
- 13 - 17
- 18 - 22
- 23 - 27
- Administrative Limit

Education | Schools 3° cycle (12-14 y.o.)



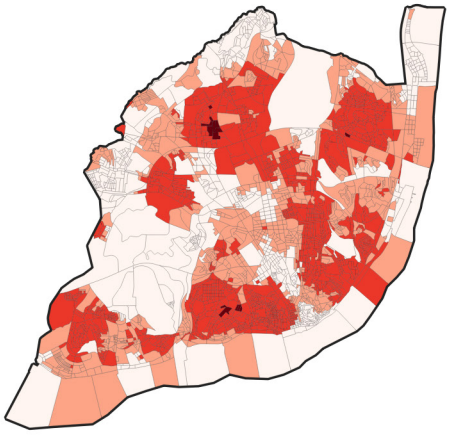
5 minute | Walking

- 0
- 1
- 2 - 3
- Administrative Limit



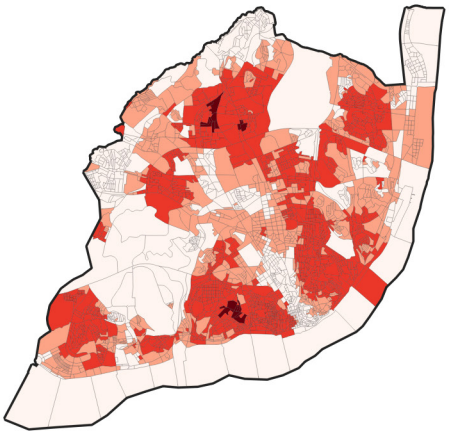
10-minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



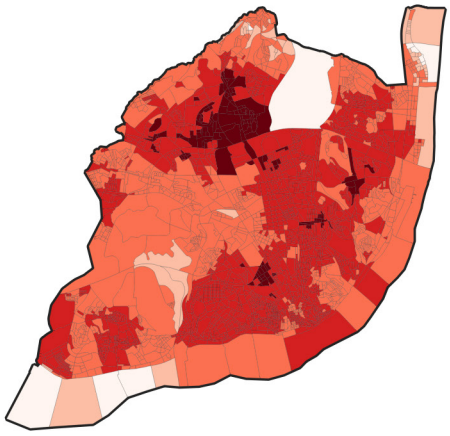
15-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 6
- Administrative Limit



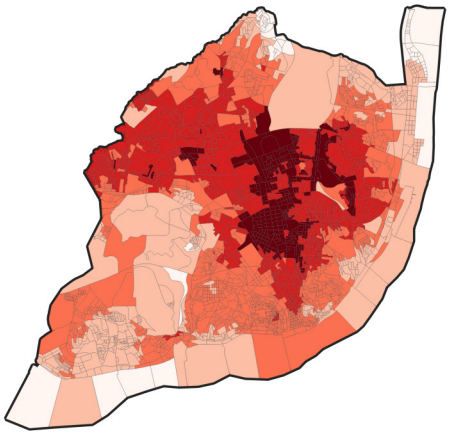
5 minute | Cycling

- 0
- 1
- 2 - 4
- 5 - 6
- Administrative Limit



10-minute | Cycling

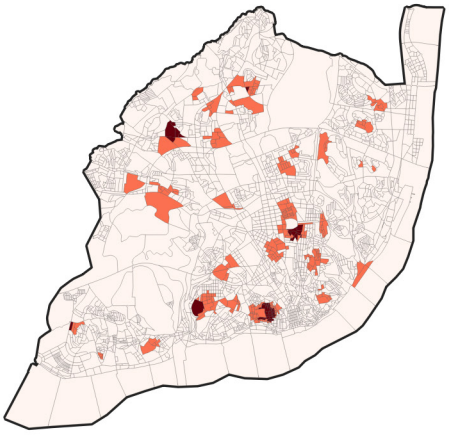
- 0
- 1
- 2 - 5
- 6 - 9
- 10 - 13
- Administrative Limit



15-minute | Cycling

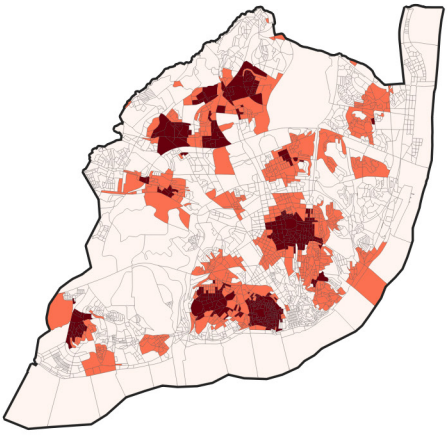
- 2 - 6
- 7 - 10
- 11 - 14
- 15 - 18
- 19 - 24
- Administrative Limit

Education | Secondary schools (15-18 y.o.)



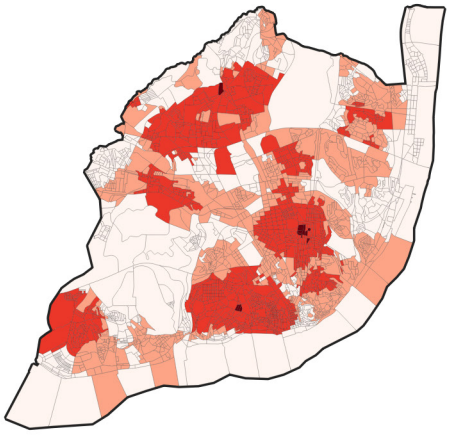
5 minute | Walking

- 0
- 1
- 2 - 3
- Administrative Limit



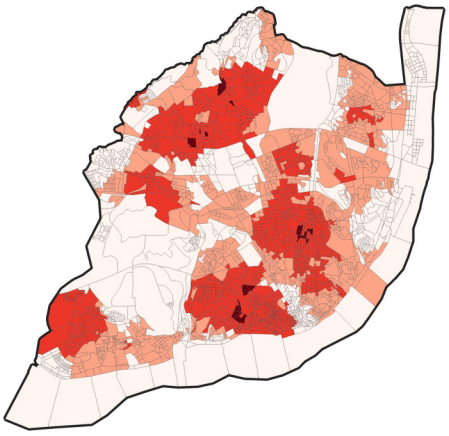
10-minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



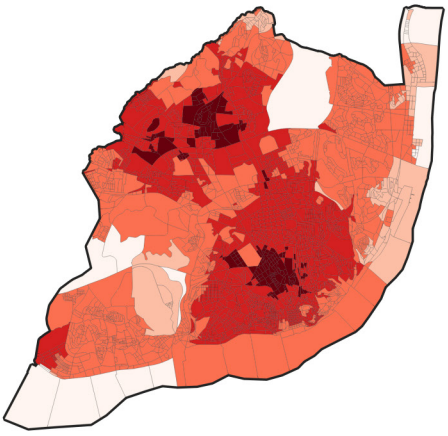
15-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 6
- Administrative Limit



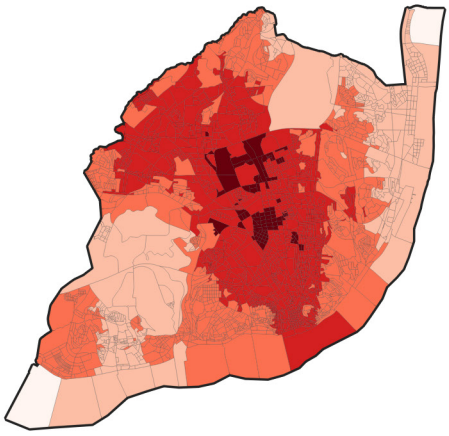
5 minute | Cycling

- 0
- 1
- 2 - 4
- 5 - 6
- Administrative Limit



10-minute | Cycling

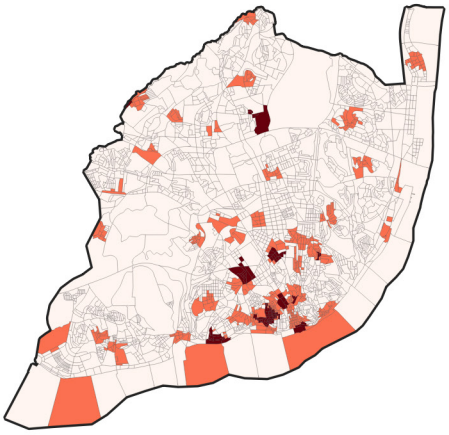
- 0
- 1
- 2 - 5
- 6 - 9
- 10 - 14
- Administrative Limit



15-minute | Cycling

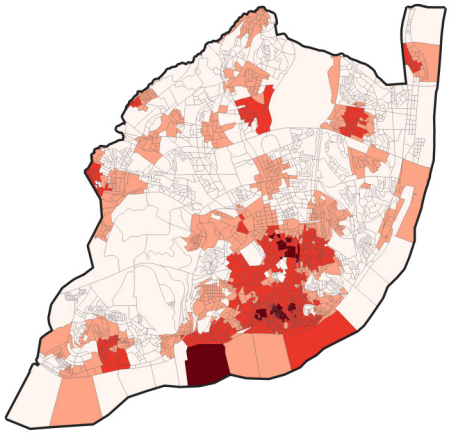
- 1
- 2 - 6
- 7 - 12
- 13 - 18
- 19 - 22
- Administrative Limit

Health and social services | Police stations



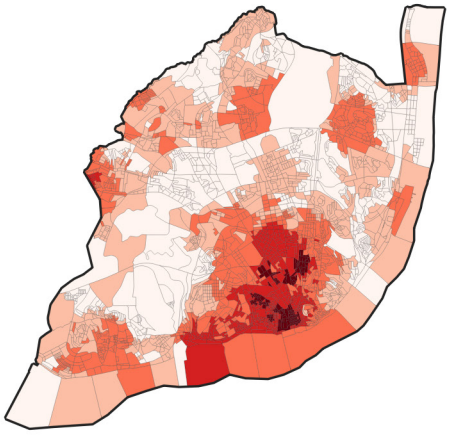
5 minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



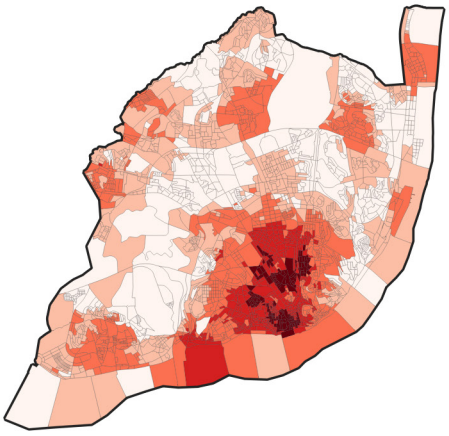
10-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 7
- Administrative Limit



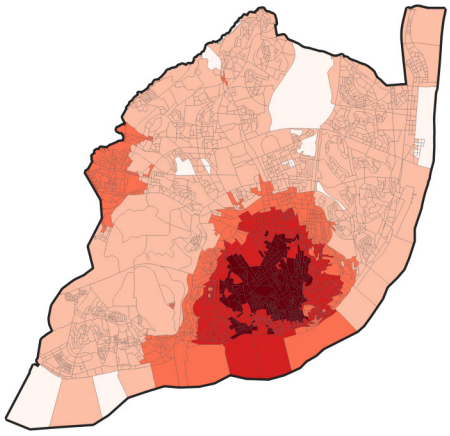
15-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 7
- 8 - 11
- Administrative Limit



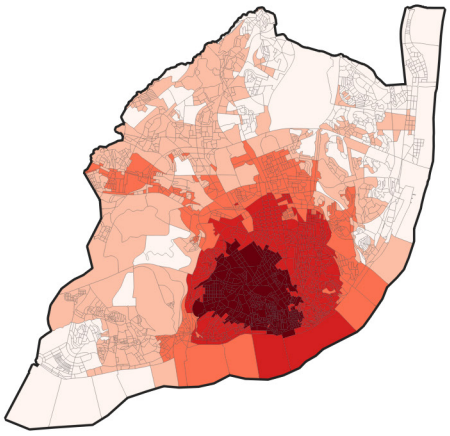
5 minute | Cycling

- 0
- 1
- 2 - 4
- 5 - 7
- 8 - 10
- Administrative Limit



10-minute | Cycling

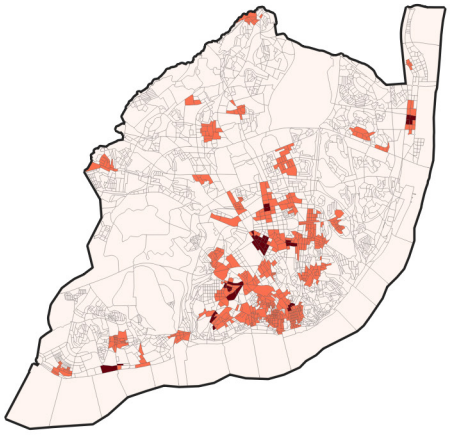
- 0 - 1
- 2 - 6
- 7 - 12
- 13 - 18
- 19 - 26
- Administrative Limit



15-minute | Cycling

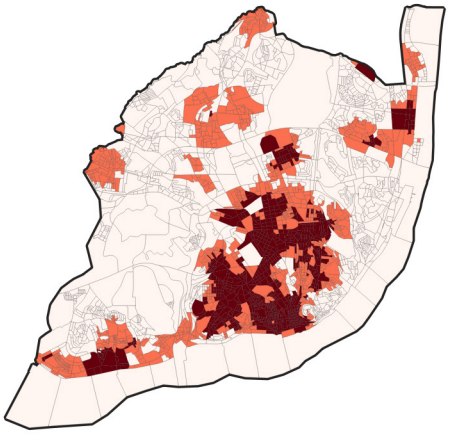
- 2 - 8
- 9 - 15
- 16 - 22
- 23 - 29
- 30 - 36
- Administrative Limit

Health and social services | Post offices



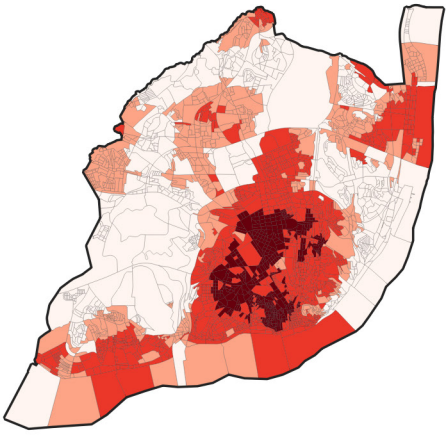
5 minute | Walking

- 0
- 1
- 2 - 3
- Administrative Limit



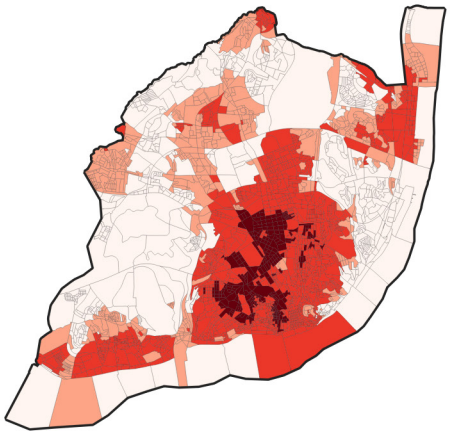
10-minute | Walking

- 0
- 1
- 2 - 5
- Administrative Limit



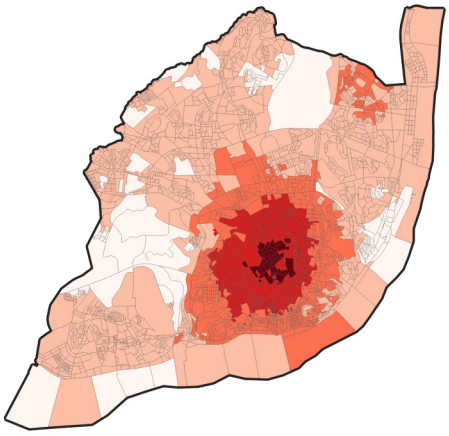
15-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 8
- Administrative Limit



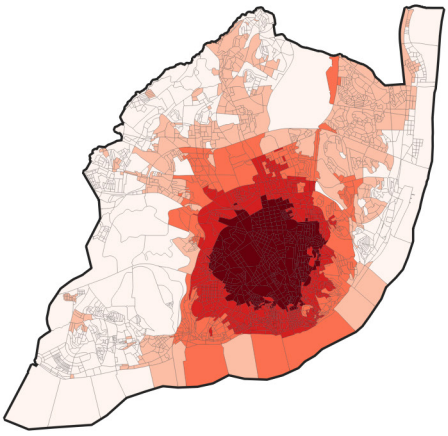
5 minute | Cycling

- 0
- 1
- 2 - 5
- 6 - 9
- Administrative Limit



10-minute | Cycling

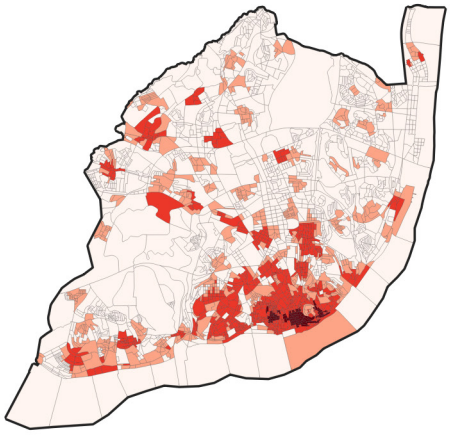
- 0 - 1
- 2 - 7
- 8 - 14
- 15 - 21
- 22 - 27
- Administrative Limit



15-minute | Cycling

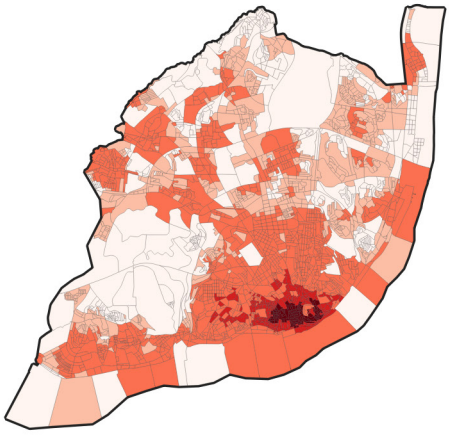
- 2 - 8
- 9 - 14
- 15 - 20
- 21 - 26
- 27 - 32
- Administrative Limit

Health and social services | Churches



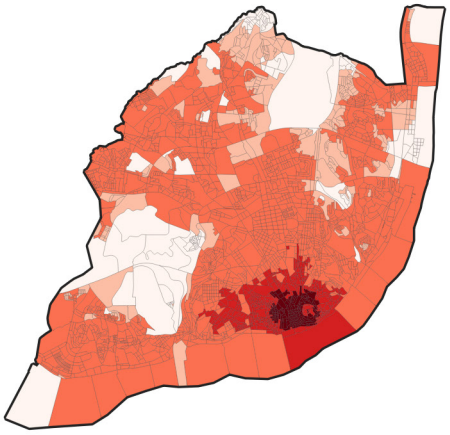
5 minute | Walking

- 0
- 1
- 2 - 6
- 7 - 11
- Administrative Limit



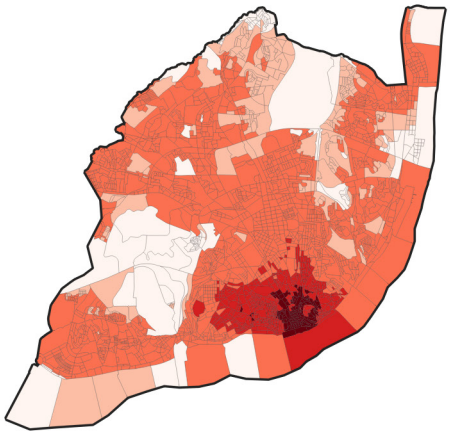
10-minute | Walking

- 0
- 1
- 2 - 10
- 11 - 19
- 20 - 29
- Administrative Limit



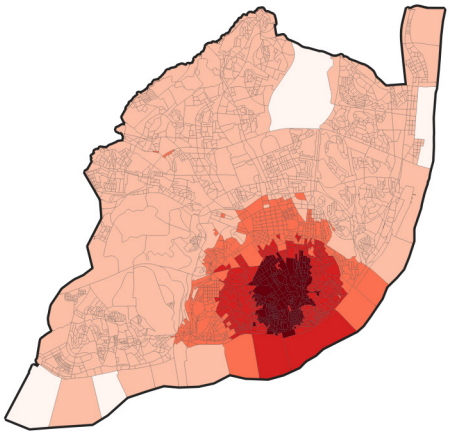
15-minute | Walking

- 0
- 1
- 2 - 17
- 18 - 33
- 34 - 48
- Administrative Limit



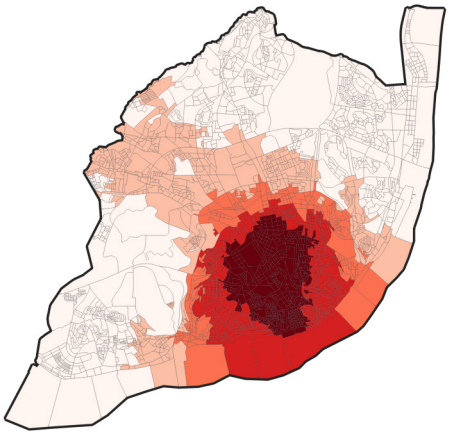
5 minute | Cycling

- 0
- 1
- 2 - 17
- 18 - 33
- 34 - 47
- Administrative Limit



10-minute | Cycling

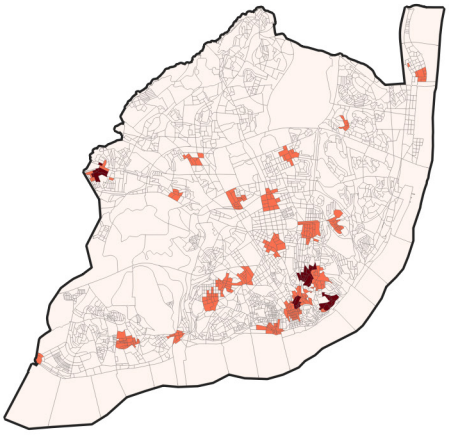
- 0 - 1
- 2 - 28
- 29 - 55
- 56 - 82
- 83 - 109
- Administrative Limit



15-minute | Cycling

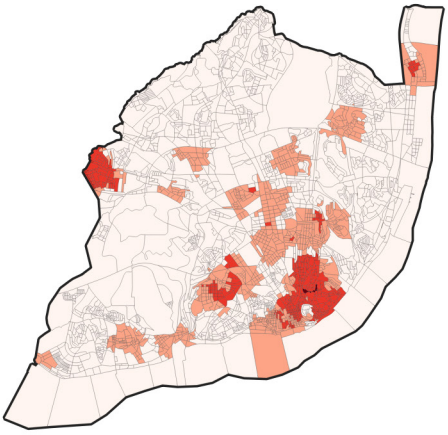
- 8 - 34
- 35 - 61
- 62 - 88
- 89 - 115
- 116 - 142
- Administrative Limit

Health and social services | Open-air markets



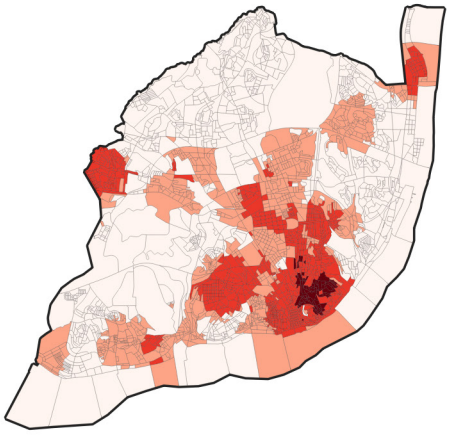
5 minute | Walking

- 0
- 1
- 2
- Administrative Limit



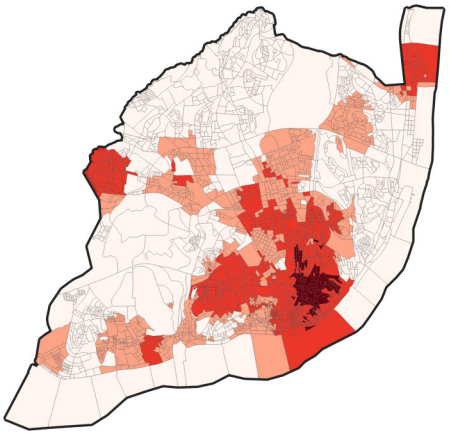
10-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 6
- Administrative Limit



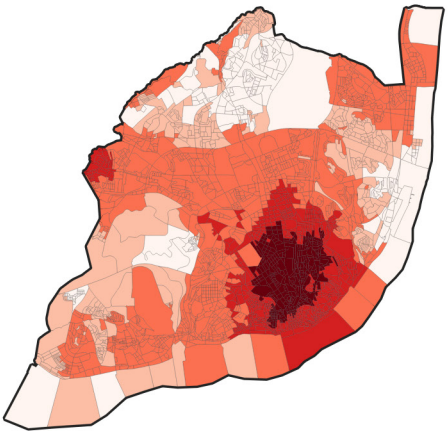
15-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 7
- Administrative Limit



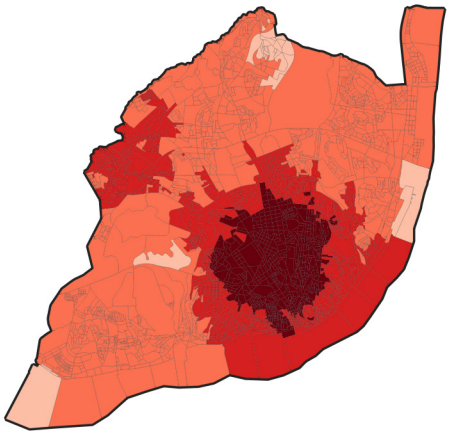
5 minute | Cycling

- 0
- 1
- 2 - 4
- 5 - 7
- Administrative Limit



10-minute | Cycling

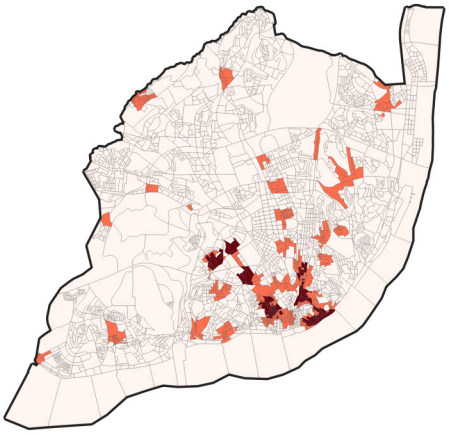
- 0
- 1
- 2 - 5
- 6 - 9
- 10 - 14
- Administrative Limit



15-minute | Cycling

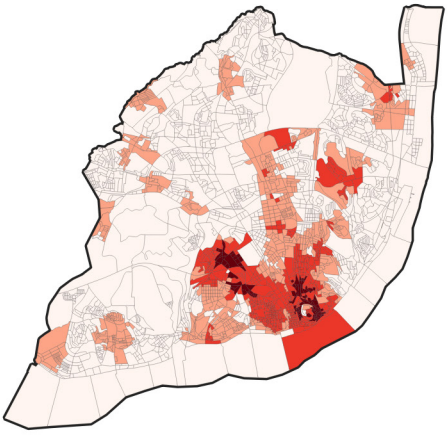
- 0
- 1
- 2 - 7
- 8 - 13
- 14 - 19
- Administrative Limit

Health and social services | Social facilities



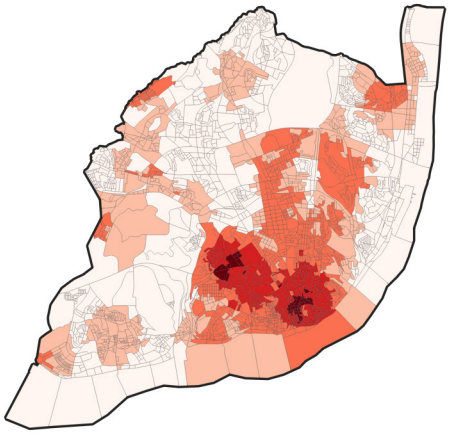
5 minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



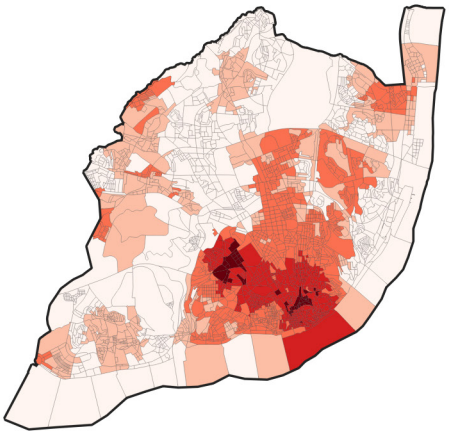
10-minute | Walking

- 0
- 1
- 2 - 4
- 5 - 8
- Administrative Limit



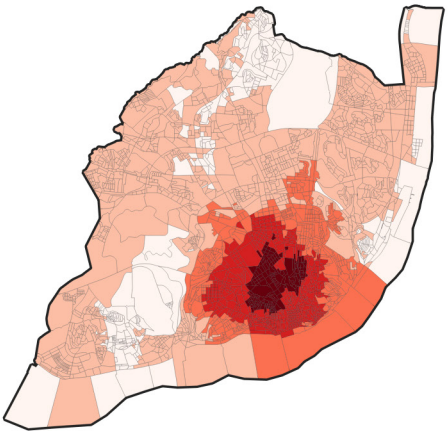
15-minute | Walking

- 0
- 1
- 2 - 5
- 6 - 9
- 10 - 13
- Administrative Limit



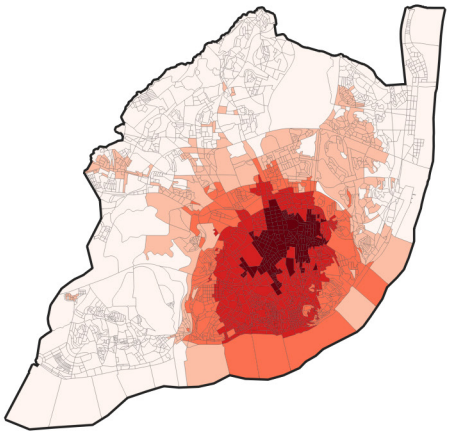
5 minute | Cycling

- 0
- 1
- 2 - 5
- 6 - 9
- 10 - 12
- Administrative Limit



10-minute | Cycling

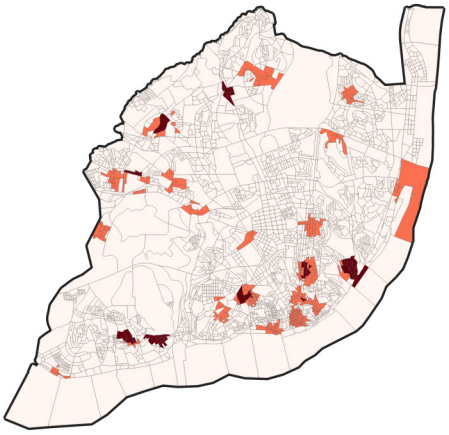
- 0 - 1
- 2 - 8
- 9 - 15
- 16 - 22
- 23 - 24
- Administrative Limit



15-minute | Cycling

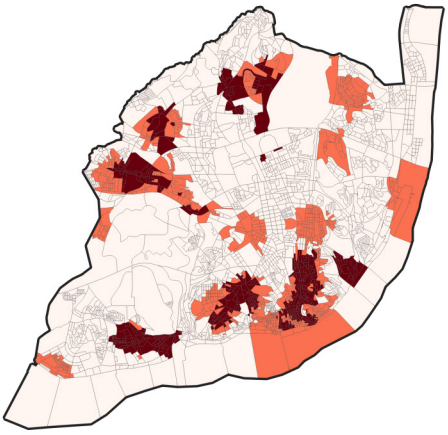
- 2 - 9
- 10 - 17
- 18 - 25
- 26 - 33
- 34 - 40
- Administrative Limit

Health and social services | Health centers (USF)



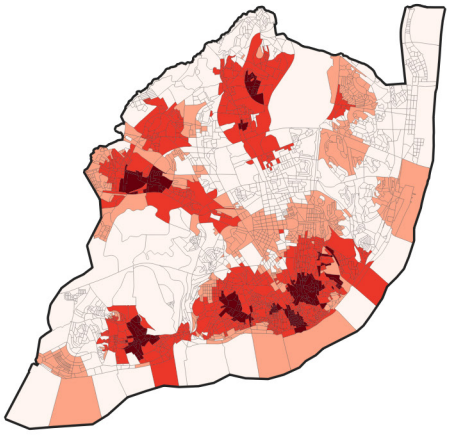
5 minute | Walking

- 0
- 1
- 2 - 3
- Administrative Limit



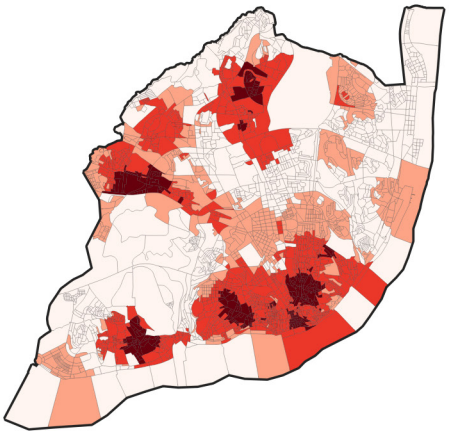
10-minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



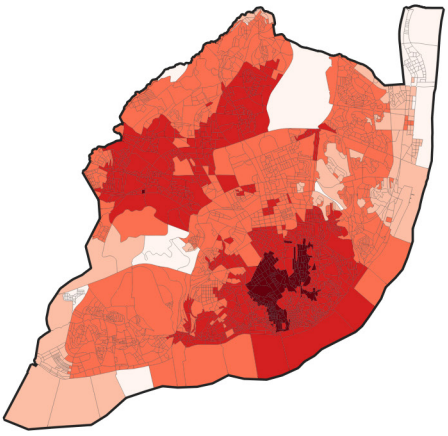
15-minute | Walking

- 0
- 1
- 2 - 3
- 4 - 5
- Administrative Limit



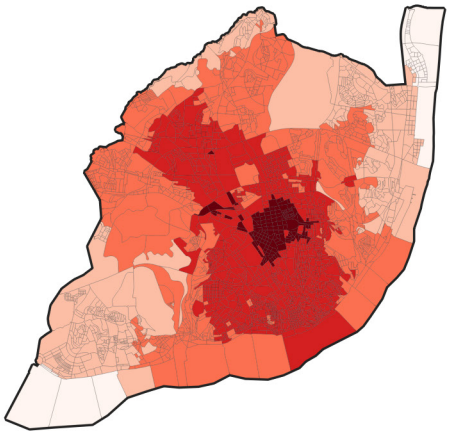
5 minute | Cycling

- 0
- 1
- 2 - 3
- 4 - 5
- Administrative Limit



10-minute | Cycling

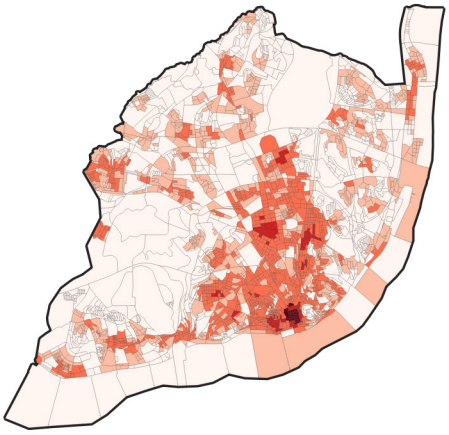
- 0
- 1
- 2 - 5
- 6 - 9
- 10 - 13
- Administrative Limit



15-minute | Cycling

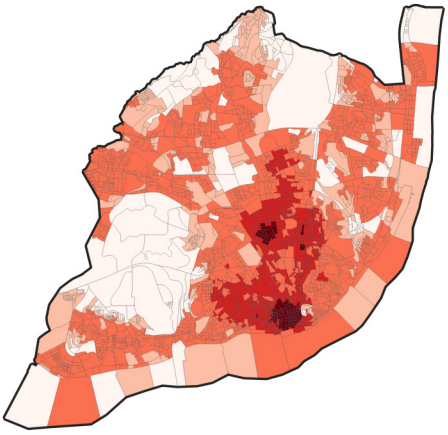
- 0 - 1
- 2 - 6
- 7 - 11
- 12 - 16
- 17 - 21
- Administrative Limit

Health and social services | Pharmacies



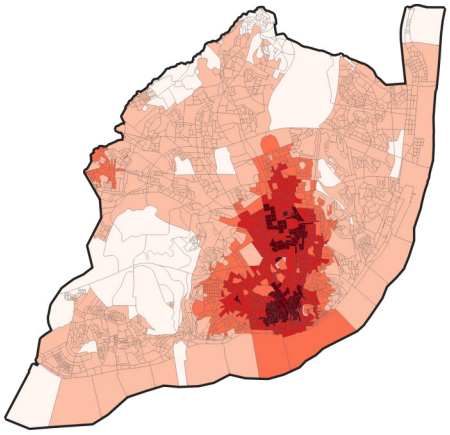
5 minute | Walking

- 0
- 1
- 2 - 5
- 6 - 9
- 10 - 13
- Administrative Limit



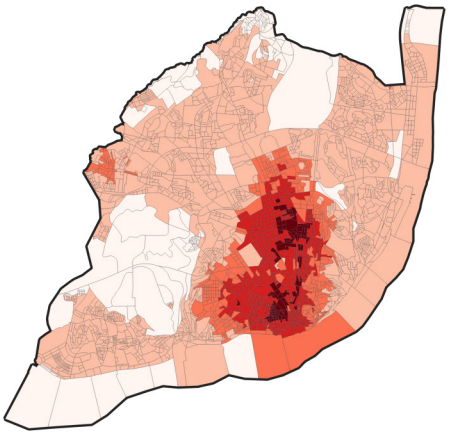
10-minute | Walking

- 0
- 1
- 2 - 9
- 10 - 17
- 18 - 24
- Administrative Limit



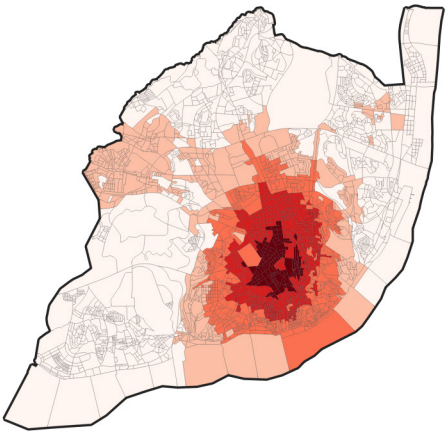
15-minute | Walking

- 0 - 1
- 2 - 11
- 12 - 21
- 22 - 31
- 32 - 42
- Administrative Limit



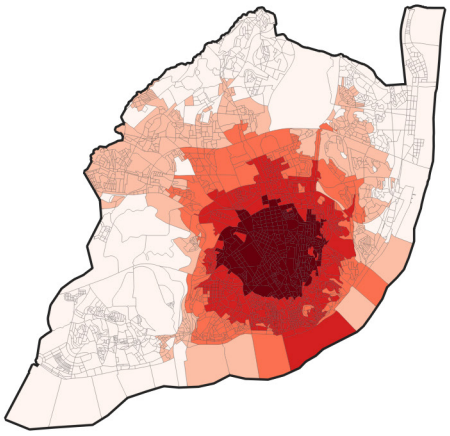
5 minute | Cycling

- 0 - 1
- 2 - 12
- 13 - 23
- 24 - 34
- 35 - 44
- Administrative Limit



10-minute | Cycling

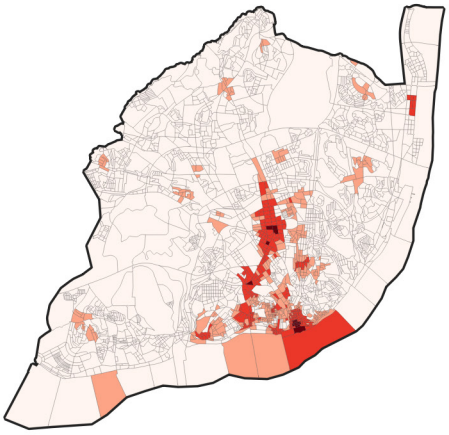
- 0 - 27
- 28 - 54
- 55 - 81
- 82 - 108
- 109 - 135
- Administrative Limit



15-minute | Cycling

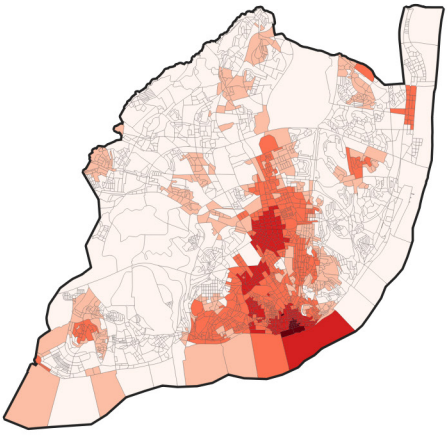
- 13 - 49
- 50 - 84
- 85 - 120
- 121 - 155
- 156 - 191
- Administrative Limit

Health and social services | Registry offices



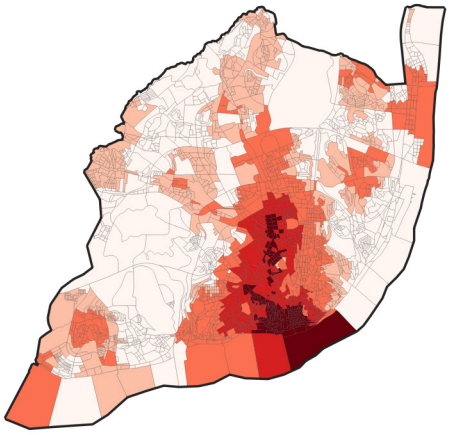
5 minute | Walking

- 0
- 1
- 2 - 5
- 6 - 8
- Administrative Limit



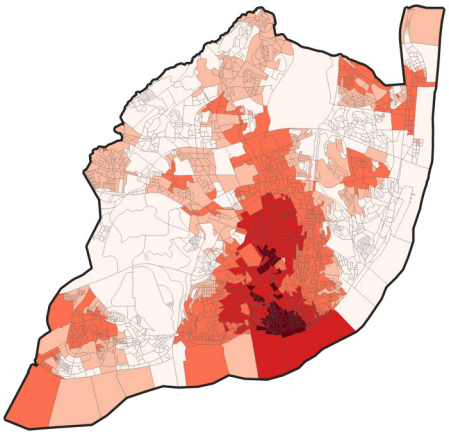
10-minute | Walking

- 0
- 1
- 2 - 6
- 7 - 11
- 12 - 15
- Administrative Limit



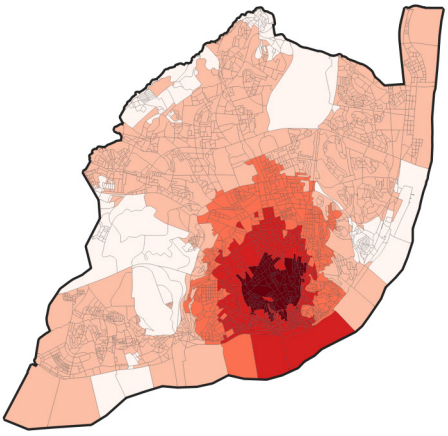
15-minute | Walking

- 0
- 1
- 2 - 7
- 8 - 13
- 14 - 20
- Administrative Limit



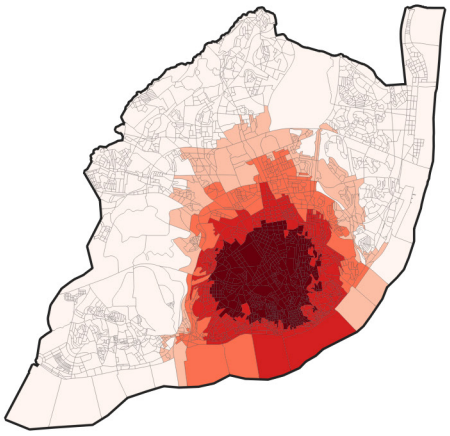
5 minute | Cycling

- 0
- 1
- 2 - 8
- 9 - 15
- 16 - 22
- Administrative Limit



10-minute | Cycling

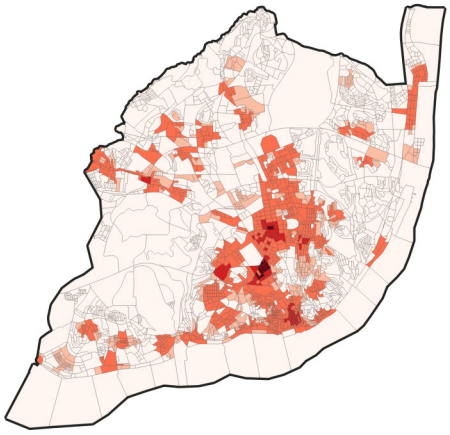
- 0 - 1
- 2 - 14
- 15 - 27
- 28 - 40
- 41 - 51
- Administrative Limit



15-minute | Cycling

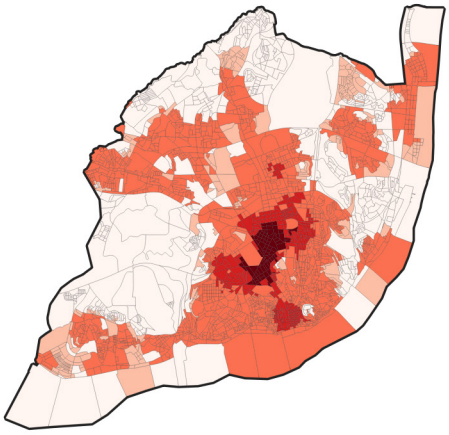
- 2 - 15
- 16 - 27
- 28 - 40
- 41 - 52
- 53 - 65
- Administrative Limit

Health and social services | Banks



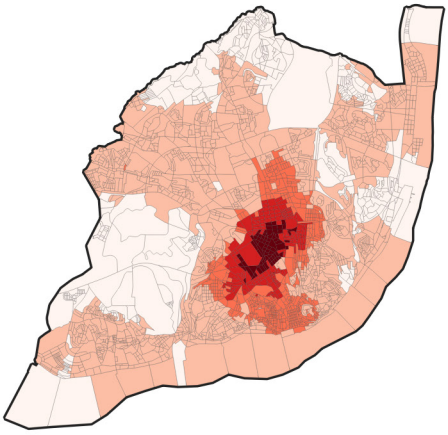
5 minute | Walking

- 0
- 1
- 2 - 8
- 6 - 15
- 10 - 22
- Administrative Limit



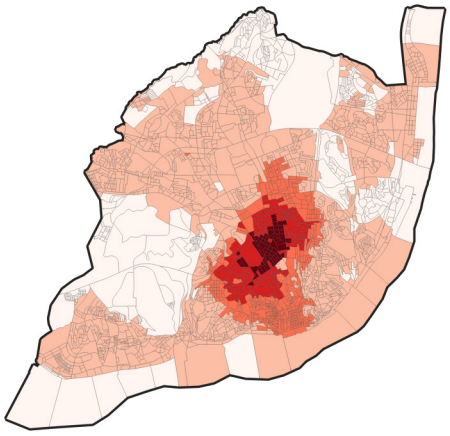
10-minute | Walking

- 0
- 1
- 2 - 14
- 15 - 27
- 28 - 41
- Administrative Limit



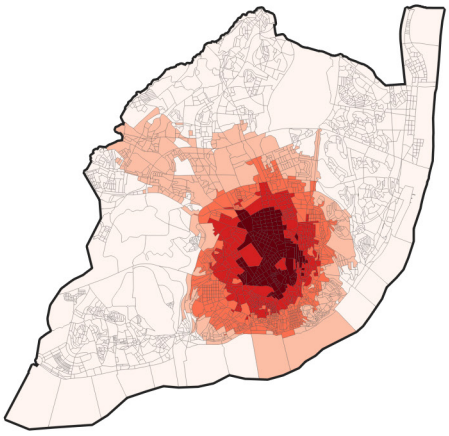
15-minute | Walking

- 0 - 1
- 2 - 18
- 19 - 35
- 36 - 52
- 53 - 67
- Administrative Limit



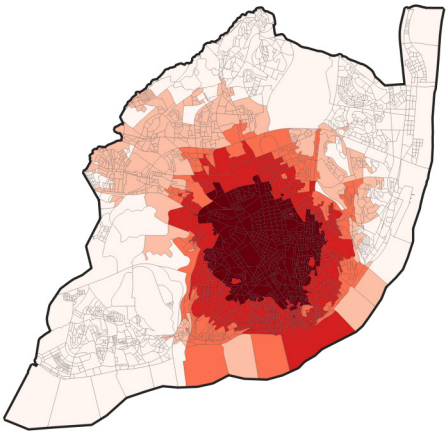
5 minute | Cycling

- 0 - 1
- 2 - 20
- 21 - 39
- 40 - 58
- 59 - 77
- Administrative Limit



10-minute | Cycling

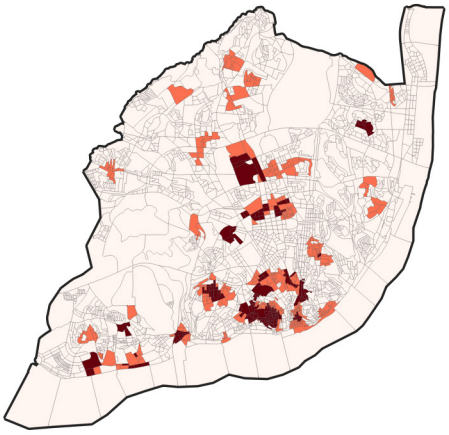
- 0 - 34
- 35 - 68
- 69 - 103
- 104 - 137
- 138 - 172
- Administrative Limit



15-minute | Cycling

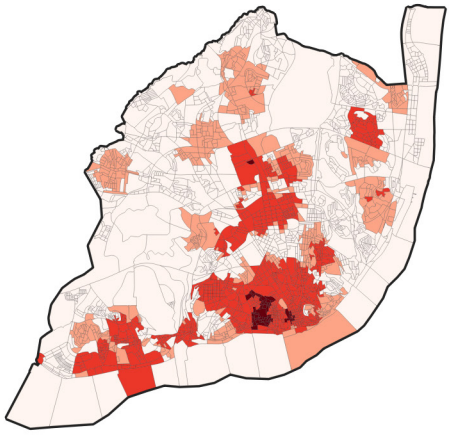
- 8 - 51
- 52 - 94
- 95 - 137
- 138 - 180
- 181 - 223
- Administrative Limit

Entertainment | Libraries



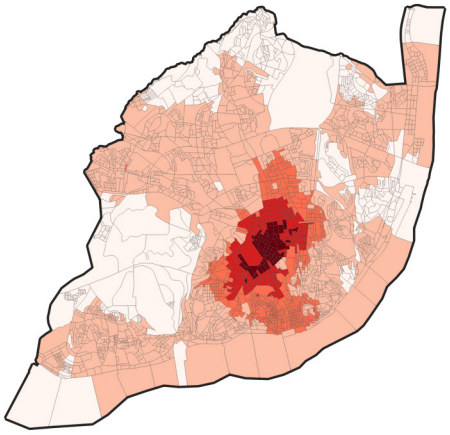
5 minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



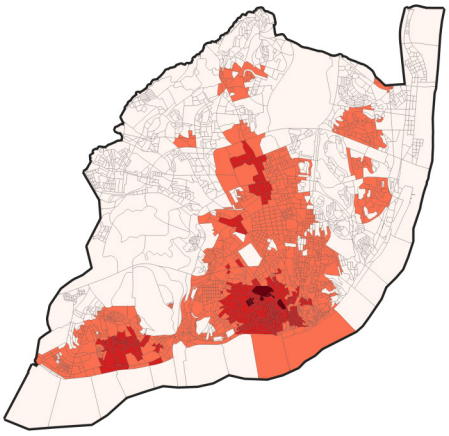
10-minute | Walking

- 0
- 1
- 2 - 5
- 6 - 9
- Administrative Limit



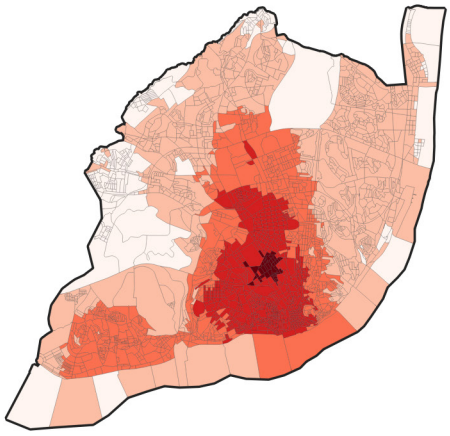
15-minute | Walking

- 0
- 1
- 2 - 6
- 7 - 11
- 12 - 14
- Administrative Limit



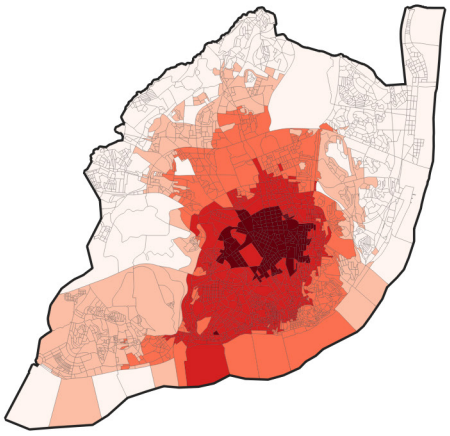
5 minute | Cycling

- 0
- 1
- 2 - 6
- 7 - 11
- 12 - 14
- Administrative Limit



10-minute | Cycling

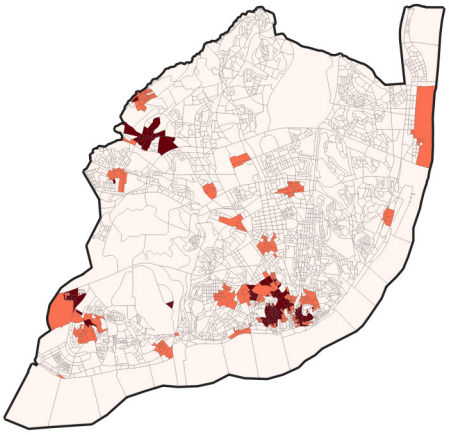
- 0 - 1
- 2 - 9
- 10 - 17
- 18 - 25
- 26 - 31
- Administrative Limit



15-minute | Cycling

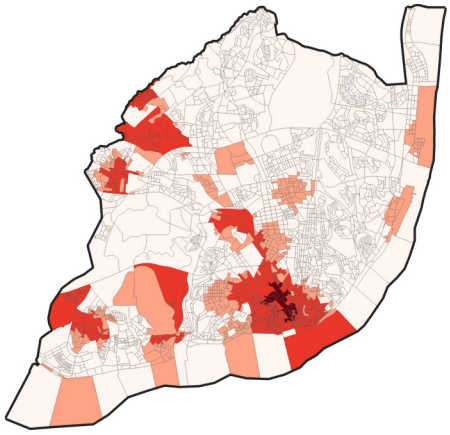
- 2 - 10
- 11 - 19
- 20 - 28
- 29 - 37
- 38 - 45
- Administrative Limit

Entertainment | Theatres



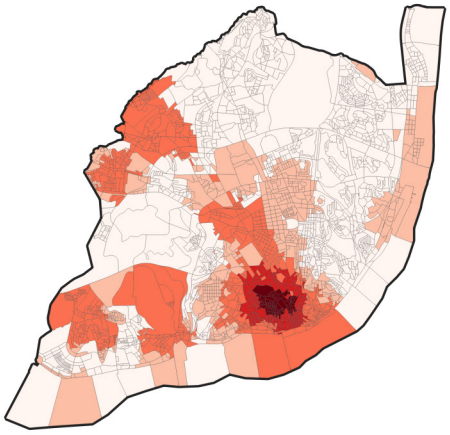
5 minute | Walking

- 0
- 1
- 2 - 4
- Administrative Limit



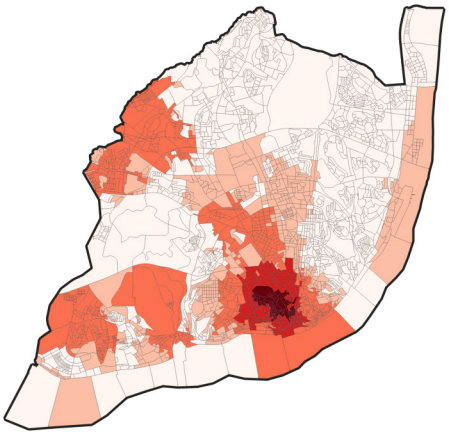
10-minute | Walking

- 0
- 1
- 2 - 6
- 7 - 11
- Administrative Limit



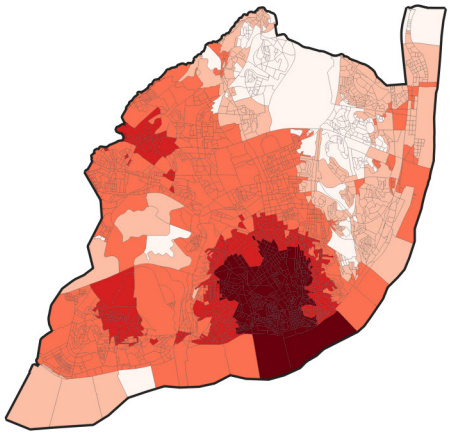
15-minute | Walking

- 0
- 1
- 2 - 6
- 7 - 11
- 12 - 15
- Administrative Limit



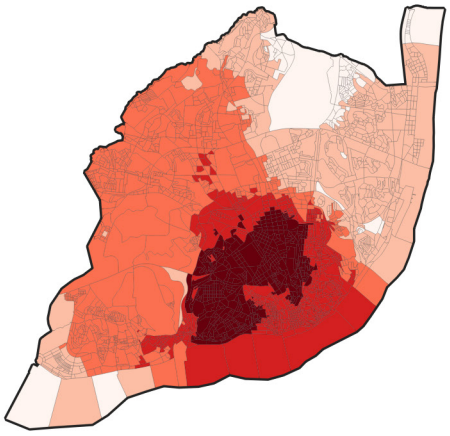
5 minute | Cycling

- 0
- 1
- 2 - 6
- 7 - 11
- 8 - 15
- Administrative Limit



10-minute | Cycling

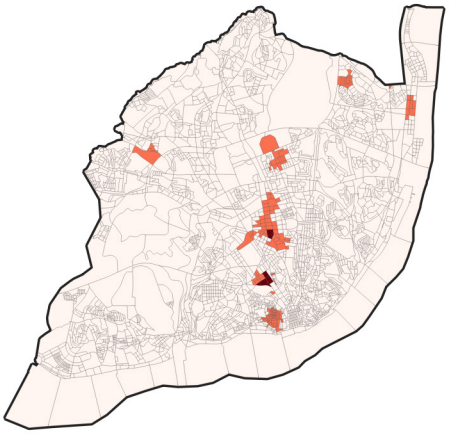
- 0
- 1
- 2 - 8
- 9 - 15
- 16 - 22
- Administrative Limit



15-minute | Cycling

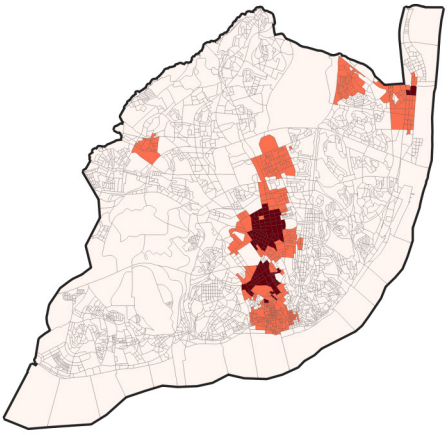
- 0 - 1
- 2 - 8
- 9 - 15
- 16 - 22
- 23 - 28
- Administrative Limit

Entertainment | Cinemas



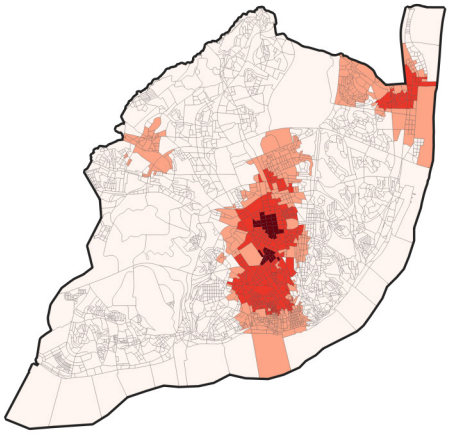
5 minute | Walking

- 0
- 1
- 2
- Administrative Limit



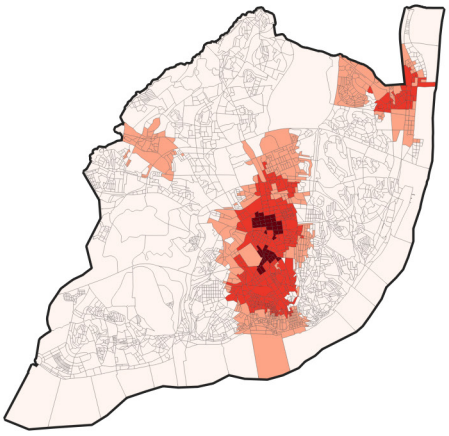
10-minute | Walking

- 0
- 1
- 3
- Administrative Limit



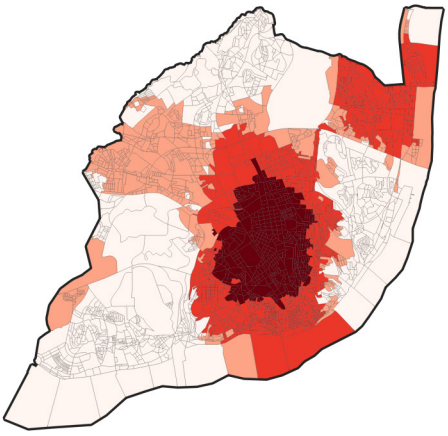
15-minute | Walking

- 0
- 1
- 2 - 3
- 4 - 5
- Administrative Limit



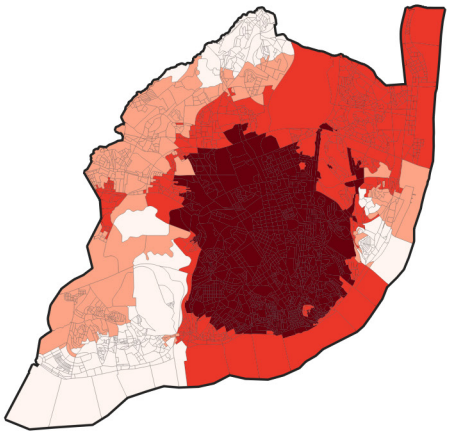
5 minute | Cycling

- 0
- 1
- 2 - 3
- 4 - 5
- Administrative Limit



10-minute | Cycling

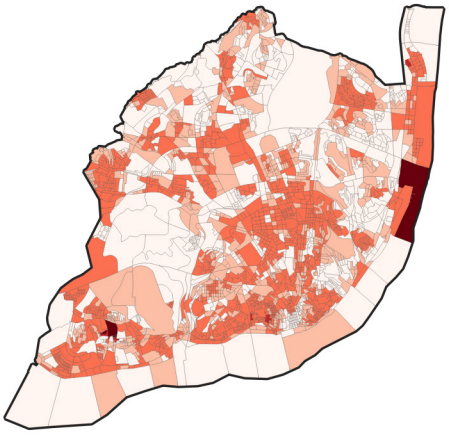
- 0
- 1
- 2 - 4
- 5 - 7
- Administrative Limit



15-minute | Cycling

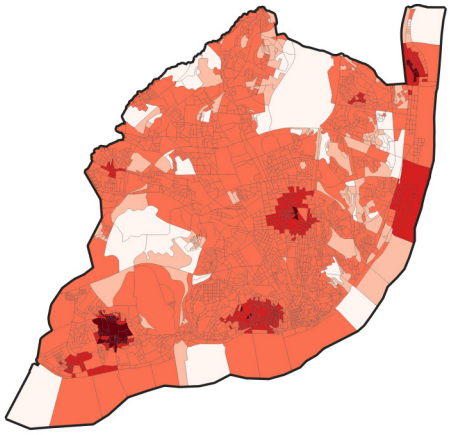
- 0
- 1
- 2 - 4
- 5 - 8
- Administrative Limit

Entertainment | Green areas



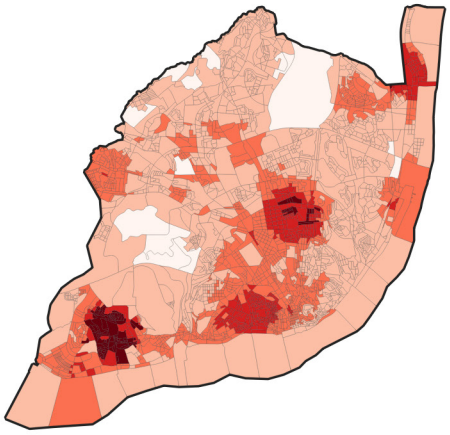
5 minute | Walking

- 0
- 1
- 2 - 13
- 14 - 25
- 26 - 37
- Administrative Limit



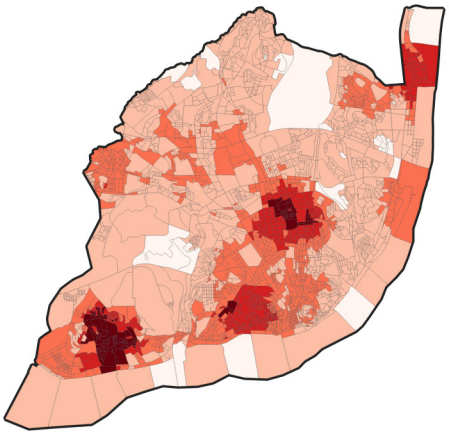
10-minute | Walking

- 0
- 1
- 2 - 16
- 17 - 31
- 32 - 45
- Administrative Limit



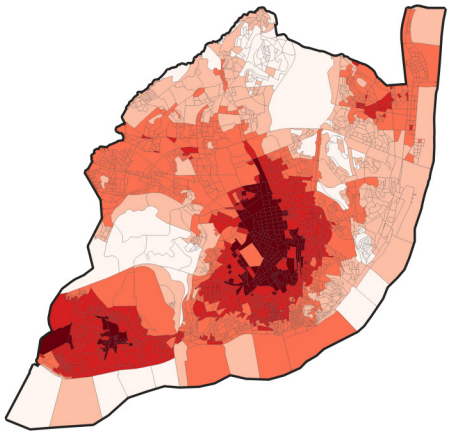
15-minute | Walking

- 0 - 1
- 2 - 17
- 18 - 33
- 34 - 49
- 50 - 63
- Administrative Limit



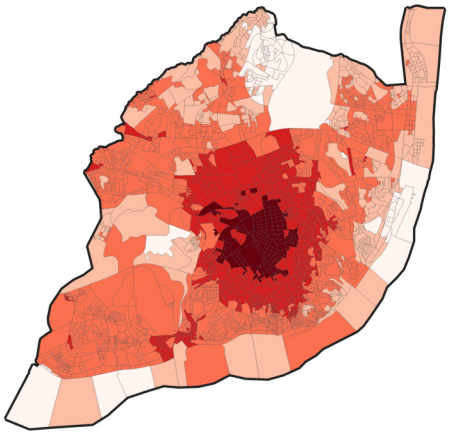
5 minute | Cycling

- 0 - 1
- 2 - 18
- 19 - 35
- 36 - 52
- 53 - 68
- Administrative Limit



10-minute | Cycling

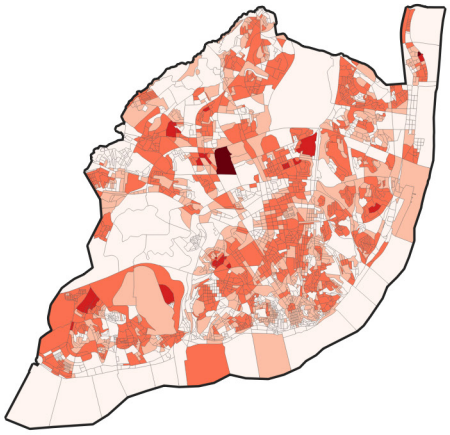
- 0 - 30
- 31 - 62
- 63 - 94
- 95 - 125
- 126 - 157
- Administrative Limit



15-minute | Cycling

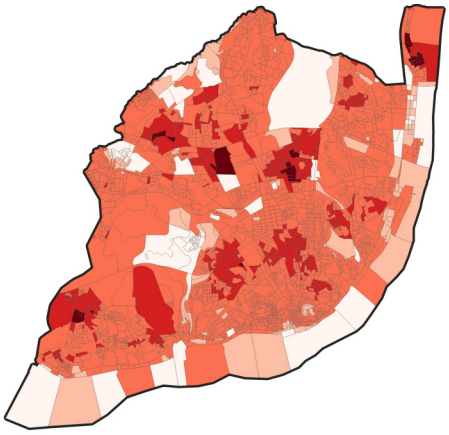
- 48 - 95
- 96 - 142
- 143 - 190
- 191 - 237
- 238 - 284
- Administrative Limit

Entertainment | Sports facilities



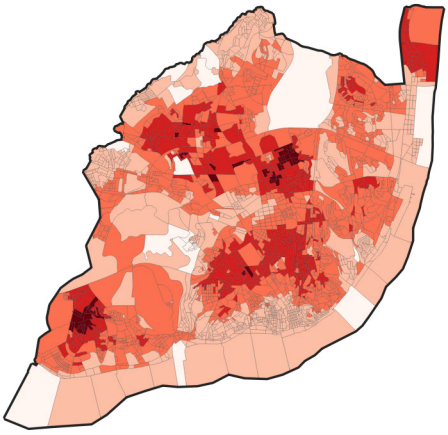
5 minute | Walking

- 0
- 1
- 2 - 7
- 8 - 14
- 15 - 18
- Administrative Limit



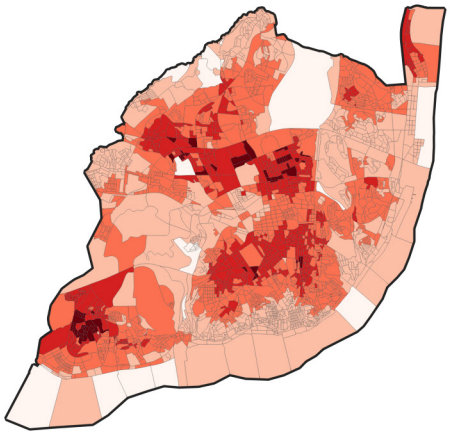
10-minute | Walking

- 0
- 1
- 2 - 10
- 11 - 19
- 20 - 28
- Administrative Limit



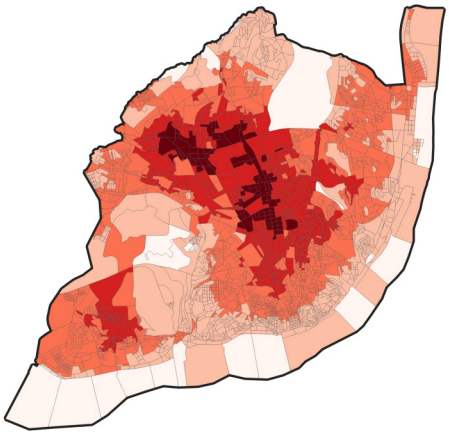
15-minute | Walking

- 0 - 1
- 2 - 11
- 12 - 21
- 22 - 31
- 32 - 42
- Administrative Limit



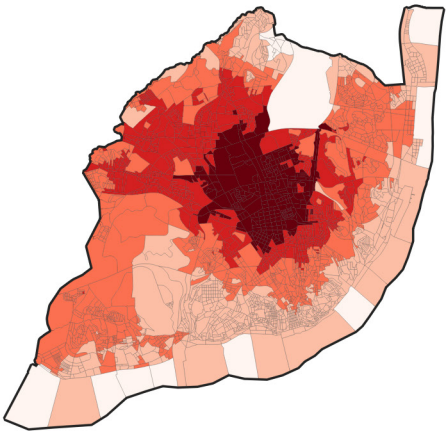
5 minute | Cycling

- 0 - 1
- 2 - 12
- 13 - 23
- 24 - 34
- 35 - 45
- Administrative Limit



10-minute | Cycling

- 0 - 29
- 30 - 58
- 59 - 87
- 88 - 116
- 117 - 145
- Administrative Limit



15-minute | Cycling

- 23 - 75
- 76 - 127
- 128 - 180
- 181 - 232
- 233 - 284
- Administrative Limit

4.2 Results

The results obtained from the procedure described above were processed following the approach used by Professor Luca Staricco (Associate Professor, Politecnico di Torino) in his article "15-, 10- or 5-minute city? A focus on accessibility to services in Turin, Italy" (Staricco, 2022). Professor L. Staricco's research focuses on pedestrian accessibility, while in the thesis the research was also extended to bicycle accessibility.
The two methodologies and their results will be analysed in Chapter 4, highlighting their potential, critical issues and possible developments.
In the following, the results obtained from the Lisbon case study will be presented.

4.2.1 Resident population having access to at least one service or more

Table 4 and 5 show the amount of population living in the delimited study area, the city of Lisbon, that has access to each of the 19 services within a 5-, 10-, or 15-minute walk or bicycle ride. From the table shown, it can be seen that on average 26.5% of the resident population accessed the 19 services within a 5-minute walk, 57% within 10 minutes and 76.1% within 15 minutes. The increase between 5 and 10 minutes is 30.5%, while between 10 and 15 minutes is 19.1%.
Concerning cycling, the percentage increases considerably. On average, 76.3% of the resident population has access to services within 5 minutes, 97.1% within 10 minutes and almost all (99.4%) within 15 minutes. The increase between 5 and 10 minutes is 20.7%, while between 10 and 15 minutes there is only a slight difference of 2.4%, as already at 10 minutes access is very high.
The results show that sports activities, green areas and pharmacies are largely accessible on foot within 5 minutes (70.1%, 70.4% and 71.9% respectively). These activities also present the highest values for the time thresholds of 10 and 15 minutes. About green areas, the result is not surprising, as the city of Lisbon won the European Green Capital Award in 2020 (Eurocid, 2020). First-cycle schools (88. 7%), houses of worship (82.2%) and banks (77.2%) also have high values within 10 minutes.

Table 4. Percentages of Lisbon's inhabitants having access to one or more locations of service within 5-, 10- or 15-minutes of walking distance

	5 min / walking			10 min / walking			15 min / walking			Δ 5-10	Δ 10-15
Accessible locations	=1	>1	≥1	=1	>1	≥1	=1	>1	≥1	≥1	≥1
Education											
Kindergartens	9.9%	1.3%	11.2%	24.8%	10.6%	35.4%	31.1%	32.9%	64.0%	24.2%	28.6%
1° Cycle schools	29.7%	7.1%	36.7%	35.0%	53.7%	88.7%	4.7%	93.0%	97.7%	52.0%	9.0%
2° Cycle schools	13.0%	1.1%	14.1%	38.2%	14.6%	52.8%	28.8%	53.8%	82.7%	38.7%	29.9%
3° Cycle schools	12.0%	1.1%	13.0%	36.3%	13.5%	49.7%	32.5%	46.8%	79.3%	36.7%	29.5%
Secondary schools	9.5%	1.5%	11.0%	32.1%	14.3%	46.3%	34.1%	39.4%	73.5%	35.3%	27.2%
Health and social services											
Police stations	15.0%	2.3%	17.2%	31.2%	19.0%	50.2%	34.1%	41.2%	75.3%	32.9%	25.1%
Post offices	18.4%	1.3%	19.7%	32.9%	21.2%	54.1%	28.1%	47.2%	75.3%	34.4%	21.2%
Churches	23.6%	16.9%	40.5%	29.1%	53.1%	82.2%	10.6%	84.6%	95.2%	41.7%	13.0%
Open-air markets	9.4%	1.6%	11.0%	27.8%	10.8%	38.6%	31.1%	29.4%	60.5%	27.6%	22.0%
Social facilities	11.0%	3.2%	14.1%	27.2%	16.3%	43.4%	27.0%	39.2%	66.2%	29.3%	22.8%
Health centers	8.7%	3.1%	11.7%	23.2%	17.0%	40.2%	23.0%	41.9%	65.0%	28.5%	24.8%
Pharmacies	36.0%	35.9%	71.9%	12.4%	83.2%	95.6%	3.2%	96.0%	99.2%	23.7%	3.6%
Register offices	12.1%	4.2%	16.2%	20.9%	22.0%	42.9%	29.4%	40.2%	69.6%	26.7%	26.7%
Banks	13.1%	32.8%	45.9%	9.0%	68.1%	77.2%	5.3%	84.9%	90.1%	31.2%	13.0%
Entertainment											
Libraries	11.6%	4.8%	16.4%	25.8%	25.1%	50.9%	30.1%	48.9%	78.9%	34.4%	28.1%
Theatres	7.0%	2.1%	9.1%	13.5%	12.9%	26.5%	23.0%	25.5%	48.5%	17.3%	22.0%
Cinemas	3.2%	0.1%	3.3%	11.0%	2.8%	13.9%	15.0%	10.4%	25.3%	10.6%	11.5%
Green areas	28.3%	42.1%	70.4%	6.1%	91.4%	97.5%	0.4%	99.4%	99.8%	27.1%	2.3%
Sports facilities	28.5%	41.6%	70.1%	3.7%	94.0%	97.7%	0.6%	99.2%	99.7%	27.6%	2.0%
Mean value	15.8%	10.7%	26.5%	23.2%	33.9%	57.0%	20.6%	55.5%	76.1%	30.5%	19.1%

Table 5. Percentages of Lisbon's inhabitants having access to one or more locations of service within 5, 10 or 15 minutes of cycling distance

	5 min / by bike			10 min / by bike			15 min / by bike			Δ 5-10	Δ 10-15
Accessible locations	=1	>1	≥1	=1	>1	≥1	=1	>1	≥1	≥1	≥1
Education											
Kindergartens	31.9%	33.8%	65.7%	9.1%	90.1%	99.2%	0.1%	99.9%	100.0%	33.6%	0.8%
1° Cycle schools	5.9%	92.0%	97.9%	0.0%	100.0%	100.0%	0.0%	100.0%	100.0%	2.1%	0.0%
2° Cycle schools	26.3%	54.1%	80.4%	0.7%	99.2%	99.9%	0.0%	100.0%	100.0%	19.5%	0.1%
3° Cycle schools	30.0%	47.5%	77.5%	1.6%	98.2%	99.7%	0.0%	100.0%	100.0%	22.2%	0.3%
Secondary schools	34.7%	41.7%	76.5%	4.3%	95.2%	99.6%	0.0%	100.0%	100.0%	23.1%	0.4%
Health and social services											
Police stations	32.0%	42.3%	74.2%	0.9%	99.0%	99.9%	0.0%	100.0%	100.0%	25.6%	0.1%
Post offices	25.5%	49.6%	75.0%	3.9%	95.8%	99.8%	0.0%	100.0%	100.0%	24.7%	0.2%
Churches	11.2%	84.5%	95.8%	0.0%	100.0%	100.0%	0.0%	100.0%	100.0%	4.2%	0.0%
Open-air markets	28.7%	33.2%	61.9%	15.3%	74.7%	90.0%	0.8%	99.2%	100.0%	28.1%	10.0%
Social facilities	25.1%	41.9%	67.0%	11.3%	88.1%	99.4%	100.0%	0.0%	100.0%	32.4%	0.6%
Health centers	23.8%	43.7%	67.5%	6.2%	91.6%	97.9%	1.6%	98.3%	99.9%	30.3%	2.0%
Pharmacies	2.9%	96.3%	99.2%	0.0%	100.0%	100.0%	0.0%	100.0%	100.0%	0.8%	0.0%
Register offices	27.7%	41.9%	69.6%	4.1%	94.5%	98.5%	0.0%	100.0%	100.0%	29.0%	1.5%
Banks	4.9%	85.7%	90.6%	1.3%	98.6%	99.9%	0.0%	100.0%	100.0%	9.2%	0.1%
Entertainment											
Libraries	26.6%	49.4%	76.0%	7.8%	91.4%	99.2%	0.0%	100.0%	100.0%	23.2%	0.8%
Theatres	21.6%	27.0%	48.7%	20.3%	70.2%	90.5%	2.0%	97.6%	99.7%	41.9%	9.1%
Cinemas	15.4%	11.8%	27.2%	23.5%	47.0%	70.5%	17.1%	72.4%	89.5%	43.3%	19.0%
Green areas	1.2%	98.8%	99.9%	0.0%	100.0%	100.0%	0.0%	100.0%	100.0%	0.1%	0.0%
Sports facilities	0.5%	99.3%	99.8%	0.0%	100.0%	100.0%	0.0%	100.0%	100.0%	0.2%	0.0%
Mean value	19.8%	56.6%	76.3%	5.8%	91.2%	97.1%	6.4%	93.0%	99.4%	20.7%	2.4%

The least accessible services are in the cultural field: cinemas and theatres. They can be reached within 5 minutes by 3.3% and 9.1% of the population respectively, up to 25.3% and 48.5% within 15 minutes.
In general, it can be seen that within 5-minutes, except for the services mentioned above, the other services are reachable by no more than 20% of the population. Within 15-minutes on foot (excluding theatres and cinemas) all other activities are reachable by at least 60% of the population.
Looking at the results concerning cycling mobility, the situation is rather homogeneous. Schools, churches, pharmacies, banks, green areas and sporting activities are already accessible to more than 90% of the population within the 5-minute cycle limit. Cinemas and theatres, on the other hand, maintain a low percentage of 27.2% and 48.7% respectively. Within 10-minutes, all services, except for cinemas (70.5%), are accessible to at least 90% of the population, with up to 100% coverage within 15 minutes for almost all activities (cinemas: 89.5%).
The data on cycling are very interesting as they show that the existing services can be reached within a short time threshold, yet the IMOB 2017 mobility survey shows that only 0.6 % of the population of the city of Lisbon uses bicycles for their trips (INE, 2018). Other elements (e.g. presence of bicycle lanes, road safety, etc.) should therefore be investigated to see which elements should be changed to encourage citizens to use this method of travel more.

4.2.2 Resident population having access to multiple locations

The graphs below show the amount of the population that can access by foot (Figure 45) or bike (Figure 46) a certain number of locations for each service within 15-minutes.
When considering, for example, first-cycle schools, it can be seen that 70.1% of the population can choose from 2 to 5 schools within a 15-minute walk and 22.9% have a choice of at least 6 different schools. 21% of the population has a choice of more than 20 pharmacies and most residents (78.1%) have access to more than 10 sports activities. Some activities are less present and uneven across the territory: only 25.6% of the population has access to more than one theatre within 15 minutes (1.4% to more than 10 theatres), and 10.4% of the population has access to more than one cinema, up to a maximum of 5 different ones.

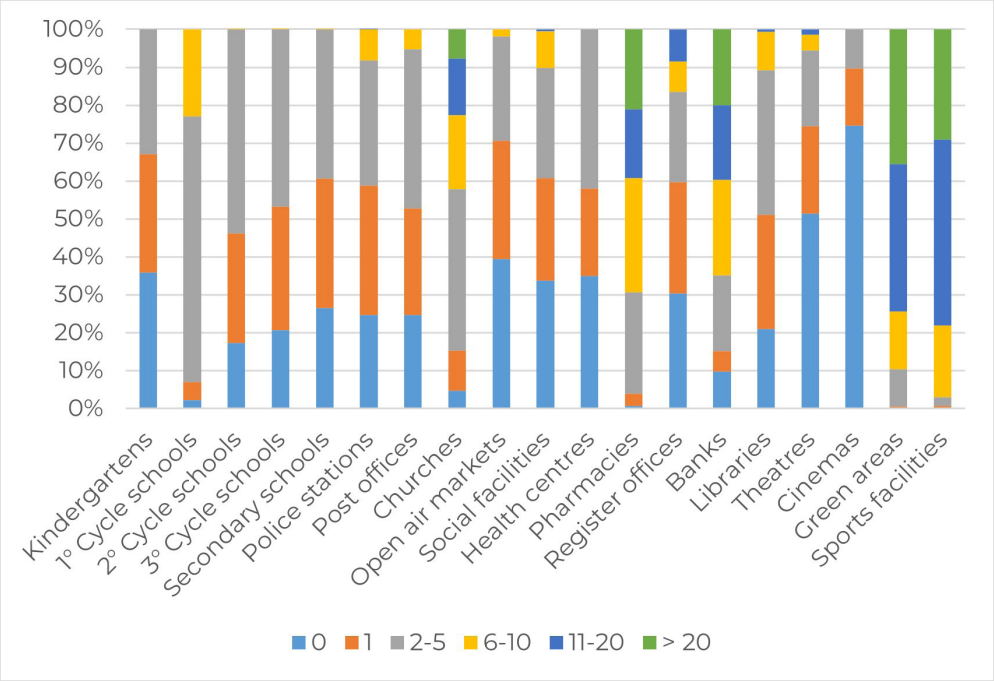


Figure 45. Percentage of the population that can access by foot a certain number of locations for each service within 15-minutes

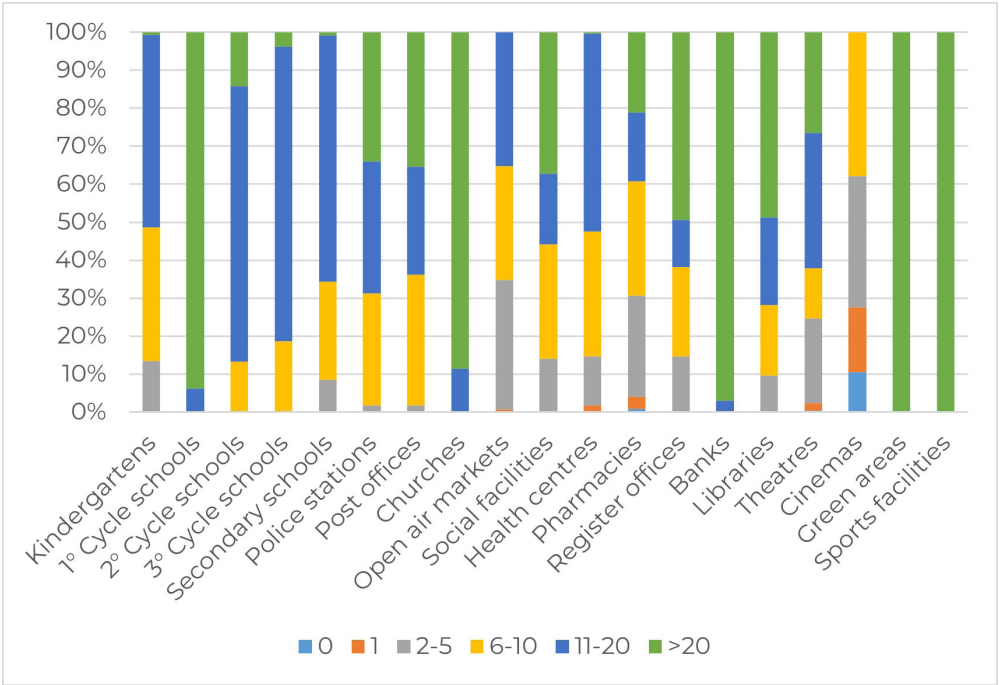


Figure 46. Percentage of the population that can access by bike a certain number of locations for each service within 15-minutes

Concerning cycling almost all residents have access to more than one service within 15-minutes by bike and more than half of the population can choose between at least 6 different destinations for each service, excluding cinemas.

4.2.3 Number of locations about the resident population served

The figures shown below indicate the relationship between the number of locations of each service and the amount of population served by that service on foot (Figure 47) and by bicycle (Figure 48) within the three-time thresholds analysed.

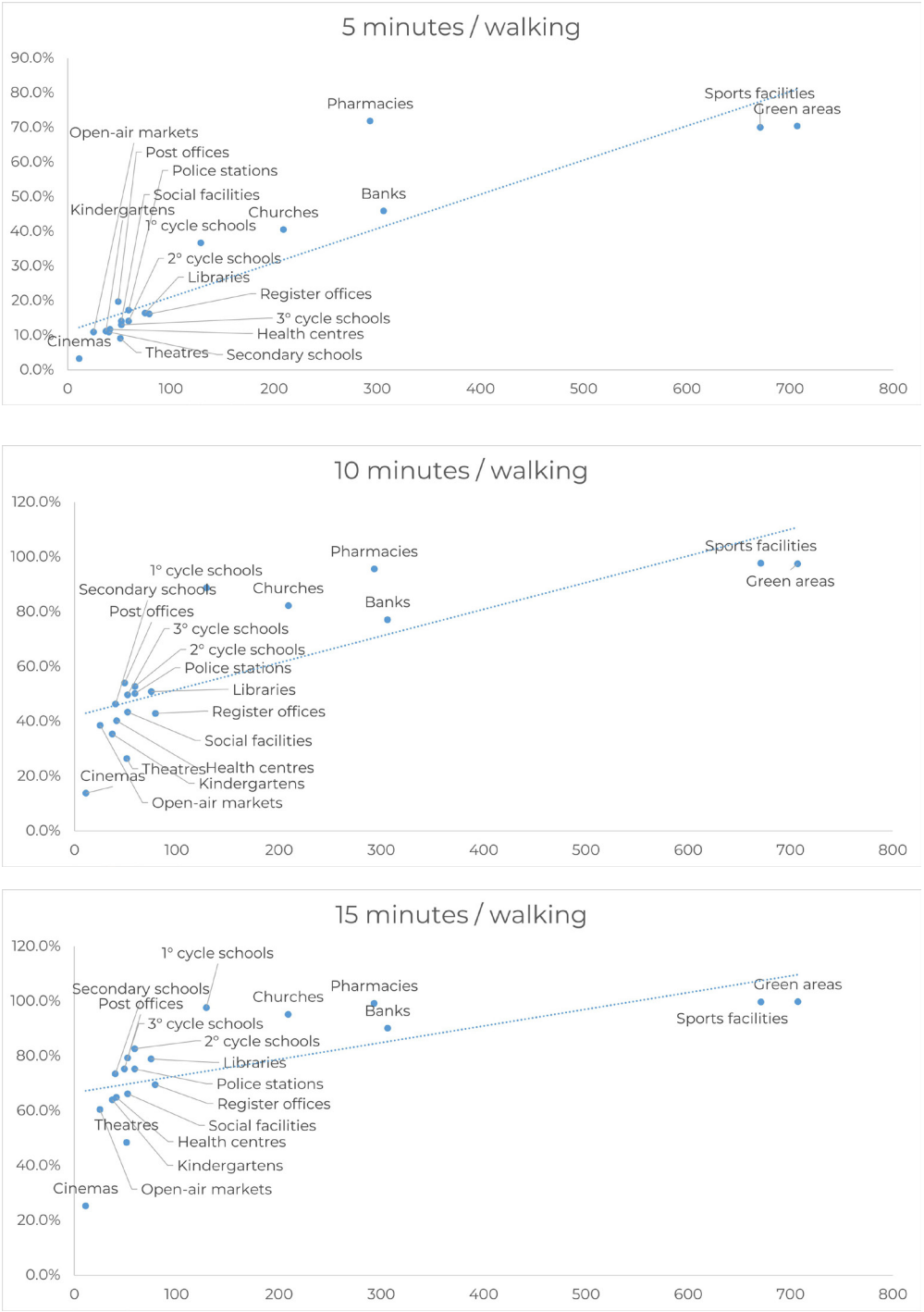


Figure 47. Relationship between the number of locations of each service (x-axis) and the percentage of the population served by this service (y-axis) within a 5, 10 and 15-minute foot

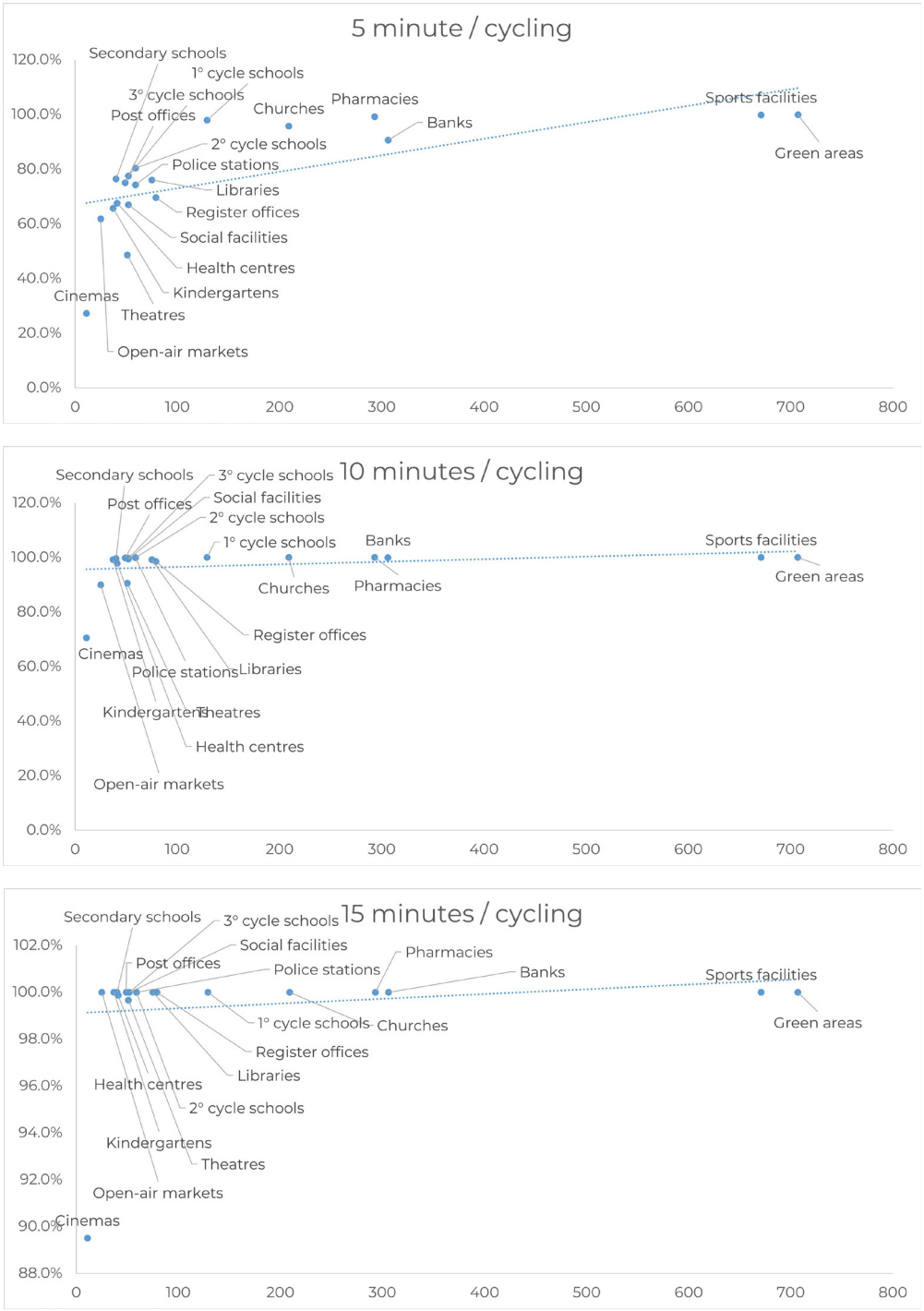


Figure 48. Relationship between the number of locations of each service (x-axis) and the percentage of the population served by this service (y-axis) within a 5, 10 and 15-minute by bike

Figures 47 and 48 relate the number of locations of each service to the percentage of the population served by that service. It can be seen that as the number of locations increases, so does the amount of population served, following a fairly linear trend, except for a few services. For example, the 293 pharmacies are accessible within a 5-minute walk for about 70% of the

population, and in the same time frame, the same amount of people have access to 671 sports activities and 707 green areas. This figure indicates that a reasoned distribution of services can have a very wide coverage, without the need for such a large number of locations.
In general, 40 locations can be considered the threshold within which approximately 40% of the population can have access to certain services within 10-minutes and approximately 75% within 15-minutes.
A further reference of interest is that first-cycle schools with 129 locations are 88.7% accessible within 10-minutes and 97.7% within 15 minutes. When compared to banks, which have more than twice as many locations (306), accessibility is higher both within 10-minutes (77.2%) and within 15-minutes (90.1%). Again, a more intelligent redistribution of services could be considered.
Theatres and third-cycle schools, which have approximately the same number of locations (51 and 52 respectively) show a clear difference in terms of accessibility. Theatres are reachable within 10 minutes by 26.5% of the population and within 15 minutes by 48.5%, while third-cycle schools are reachable within 10-minutes by 49.7% of the population and within 15-minutes by 79.3%. Nevertheless, the analysis could be deepened by assigning different weights to individual services, on the basis that not all are essential in the same way. For example, a school is a service to be used every day (for a certain segment of the population), whereas people go to the theatre less regularly.

4.2.4 Sensitivity Analysis on time thresholds

The following graph (Figure 49) shows the sensitivity analysis performed on the chosen threshold of 15-minutes, with a variation of plus or minus one minute. It shows the difference, positive or negative, in the percentage of residents who accessed at least one location of each service within 14- or 16-minutes, compared to the starting threshold of 15-minutes. This difference is expressed as a percentage and the results between the variation of one minute more (16) and one minute less (14) are almost mirror-like.
Services with locations that are widely spread throughout the territory, and thus reachable by more than 90% of the population, show a slight variation of ±1 minute between 0% and 2%.
In contrast, service locations covering a smaller percentage of the population show a greater variation of between 3% and 6%.

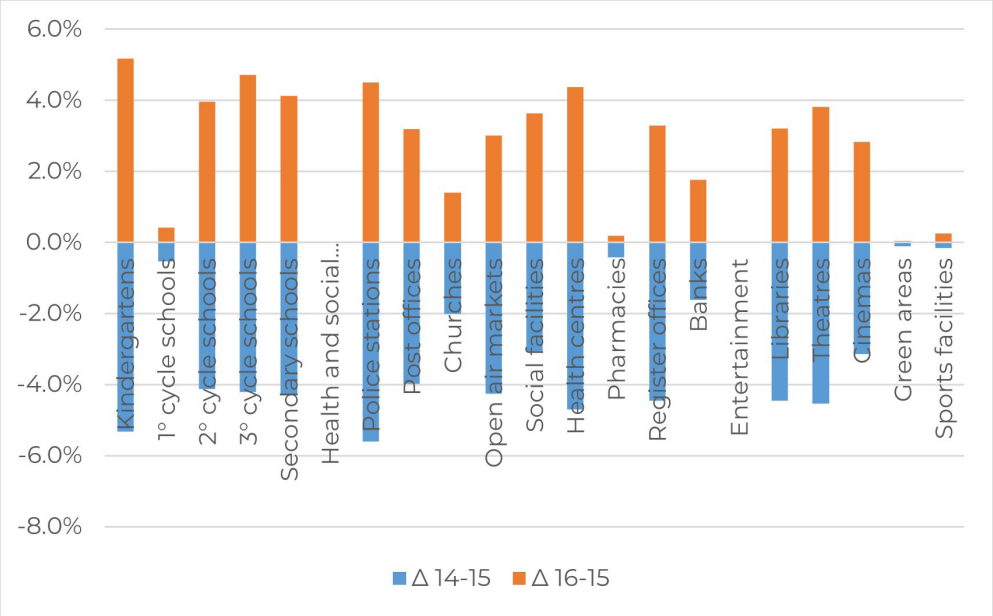


Figure 49. Change of the percentage of the population that can access a given service in 15 minutes if a 14-minute or 16-minute threshold is adopted

4.2.5 Multi-service analysis

The concept of diversity is one of the pillars of the 15-Minute City concept enunciated by Moreno and is also understood as a land-use mix.

Thus, an analysis was carried out to assess the amount of the population that can reach a certain number of different services (among the 19 considered) within a time limit of 5, 10 or 15 minutes on foot. The analysis for cycling was omitted, as almost all services are already reachable by at least 90% of the population within 10 minutes by bicycle.

Figures 50 and 51 shows how the different services accessible from each census tract through a 5-, 10- or 15-minute' walk are distributed. The limit of different services reachable within 5-minutes turns out to be 17, while within 10- and 15-minutes it rises to the maximum number of 19.

The first map shows how the services reachable within a 5-minute walk are quite heterogeneous over the territory. By 10 minutes, a greater concentration of different services in the central part of the city begins to emerge, which is made even more evident at the 15-minute threshold.

Leaving aside the census areas where there is no or very low population (Parque Florestal de Monsanto and other parks, the airport and coastal areas), it can be seen that the least served areas are mainly those to the north and east of the city.

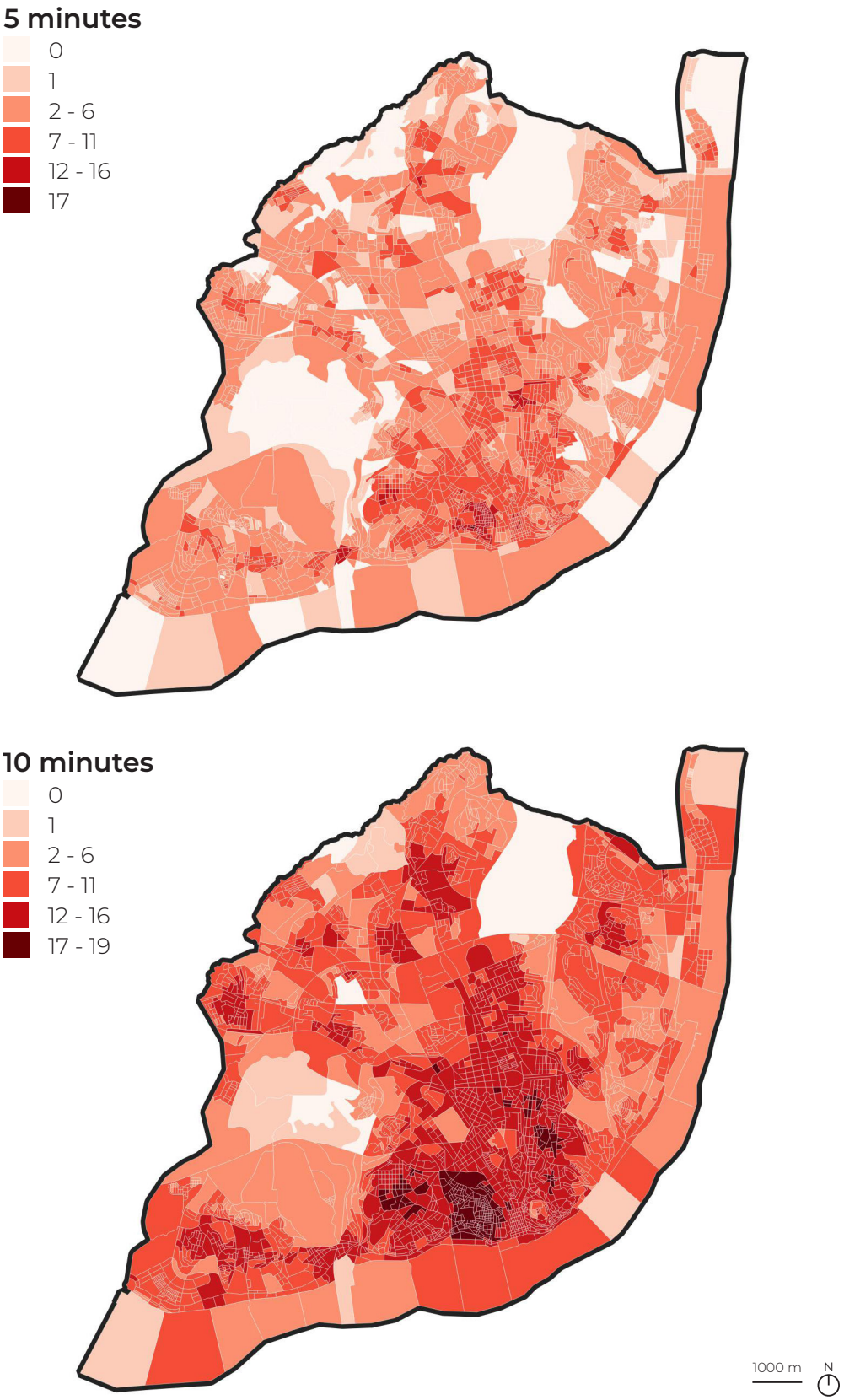


Figure 50. Different services accessible from each census tract through a 5, or 10-minute' walk

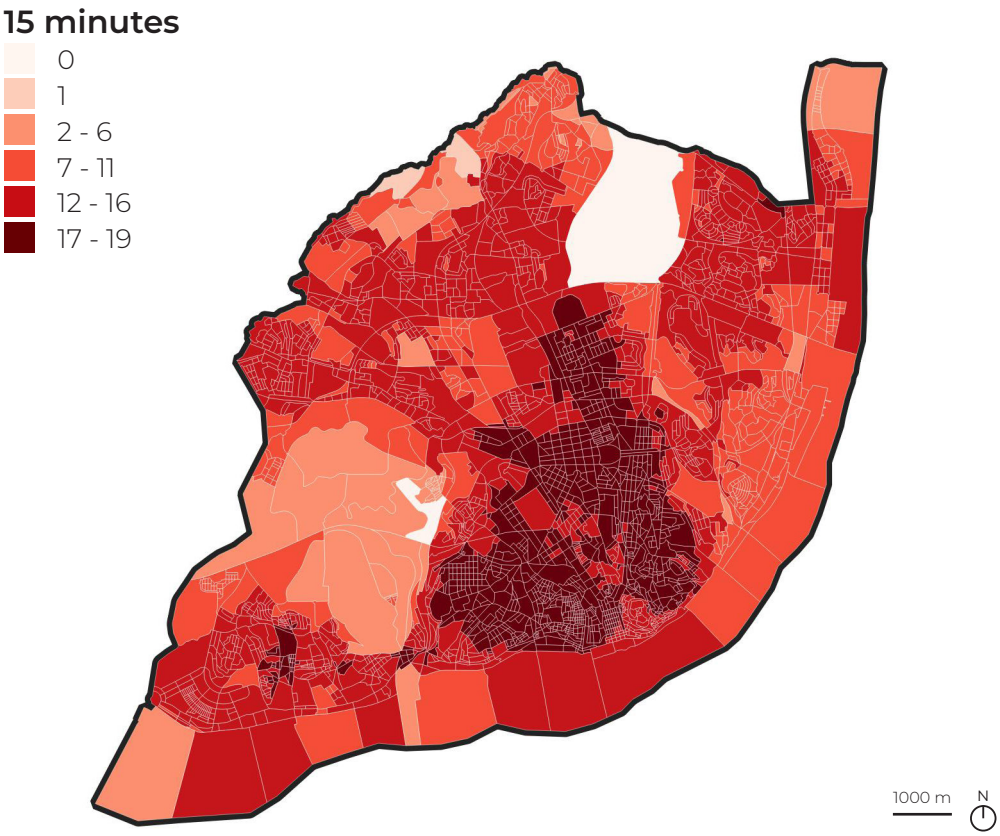


Figure 51. Different services accessible from each census tract through a 15-minute' walk

The following graph (Figure 52) shows the percentage of the population that has access to several different services (1 to 19) within a 5-, 10- or 15-minute walk.

The graph shows that more than half of the population has access to a maximum of 5 different services within 5-minutes (53%), which increases to 11 within the 10-minute limit (54.46%) and 15 within the 15-minute limit (52.84%).

Within 5-minutes, 30% of the population can choose between 7 services out of the 19 considered, only 7% between 10 different services, less than 1% can reach 13 and none have access to all 19 different services.

Within 10-minutes about 26% of the population can access 14 different services, about 6% can choose from 17 services and less than 1% have access to all of them.

Within 15-minutes, more than 30% can choose between 17 different services and about 7% can access all of them.

As the time limit increases, the possibility for residents to access different types of service increases progressively. For example, 10 services, which are about half of the total number, are accessible within 5-minutes by 7% of the population, within 10-minutes by 63% of the population and within 15-minutes by 94%.

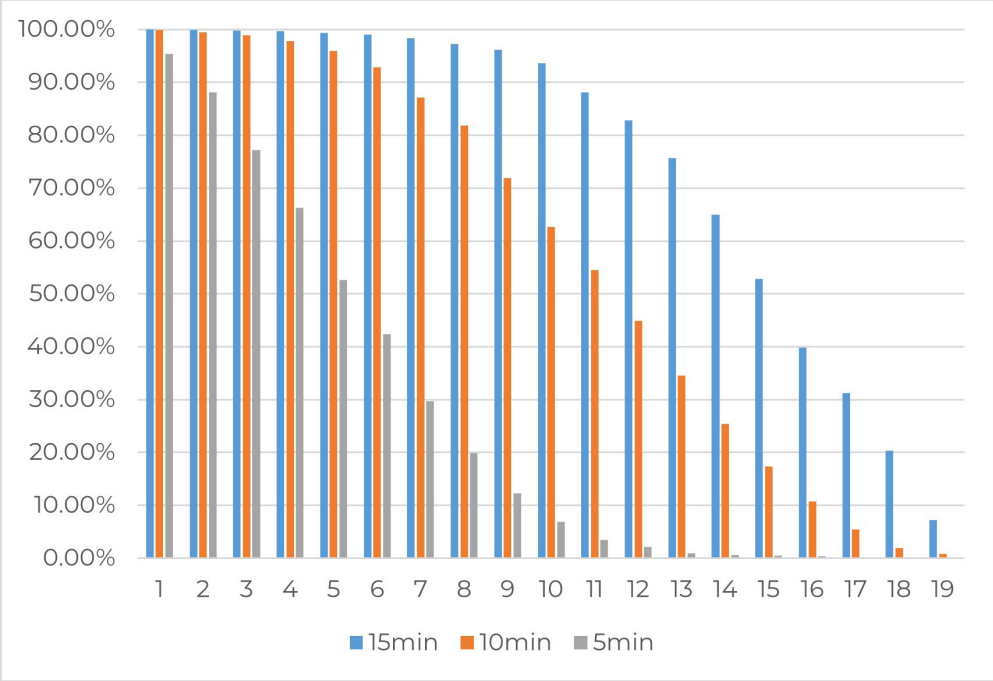


Figure 52. Percentage of Lisbon's population (y-axis) that can access at least a certain number of different services (x-axis) through a 5-, 10- or 15-minute' walk

Chapter 5
Comparison between Lisbon and Turin

This chapter aims to compare the methodologies used and results obtained from the analysis of accessibility in Lisbon proposed in this thesis, and Turin, proposed in the article "15-, 10- or 5-minute city? A focus on accessibility to services in Turin, Italy", written by Professor Luca Staricco (Staricco, 2022).
The two European cities lend themselves to comparison on this topic, presenting similar size and population density. Turin has approximately 864,000 inhabitants over 130 km² and a total density of 66 inhabitants per hectare (Staricco, 2022), while Lisbon has approximately 546,000 inhabitants over 100 km² and a total density of 55 inhabitants per hectare (CML, 2023). Both are highly car-dependent, in the case of Turin the modal share reached 37% and in Lisbon 45% (Staricco, 2022; INE, 2017).

5.1 Methodology comparison

The methodology used in this thesis has already been explored in depth in the previous chapter. Professor Staricco, in the article analysed, chooses census tracts (as in the case of Lisbon) as the partition of the city, and we find rather similar values, shown in the table below (Table 6).

Table 6. Comparison of the values of the respective census tracts of Turin and Lisbon
Source 1: Source: Staricco, L. (2022). 15-, 10- or 5-minute city? A focus on accessibility to services in Turin, Italy. *Journal of Urban Mobility, 2*, 100030. https://doi.org/10.1016/j.urbmob.2022.100030
Source 2: Câmara Municipal Lisboa. (2023). *Geodados*. https://geodados-cml.hub.arcgis.com/

	Turin	Lisbon
Average number of residents in each tract	253 (4 to 2'049), excluding sections with 0 residents	205 (1 to 1'619), excluding tracts with 0 residents
Average surface area of the tracts	33'766 m² (from a min. of 693 m² to a max. of 1'771'415 m²)	35'448 m² (from a min. of 737 m² to a max. of 3'720'783 m²)
Average residential density of inhabited stretches	18.8 residents per 1'000 m²	15.2 residents per 1'000 m²

Table 7. Locations analysed by Professor Staricco on Turin
Source: Staricco, L. (2022). 15-, 10- or 5-minute city? A focus on accessibility to services in Turin, Italy. *Journal of Urban Mobility, 2*, 100030. https://doi.org/10.1016/j.urbmob.2022.100030

Locations		Locations		Locations	
Education		**Health and social services**		**Entertainment**	
Nurseries	120	Health centers	12	Green areas	234
Kindergartens	218	Counselling centers	37	Playgrounds	285
Elementary schools	144	Social care services	151	Playrooms	30
Middle schools	87	Registry offices	15	Sports facilities	451
Secondary schools	162	Post offices	78	Libraries	20
		Police stations	25	Theatres	28
		Churches	174	Cinemas	26
		Open-air markets	42		

For the case study of Turin, the centroids of the census tracts are considered the origins of the trips and for the destinations 20 types of services are considered (Table 7). The choice of these services was because they were needed in the neighbourhood level and open georeferenced data were available from the City of Turin.
The first criterion was adopted for both cities, while the reference database chosen for Lisbon is OpenStreetMap (OSM). The use of data from the analysed city's reference municipality provides direct and precise information (data obtained directly from official censuses or which are mapped by the municipality itself) but also has disadvantages. For example, information may not be updated or may not be available in some cities that are not technologically advanced and have not yet been digitalised. OpenStreetMap, on the other hand, provides free geographic data that can be used by everyone and is periodically updated, but at the same time, this data is not always available for all areas analysed and for all services considered. OSM could also be useful for a comparison between different cities in case the same categories of services need to be analysed.
In the next section, by way of example, four services whose accessibility in Turin was analysed by Professor Staricco are selected, to compare how the results differ if open data from the municipality of origin or data from OpenStreetMap are used.
When carrying out an analysis, it is useful to consider these aspects and decide based on the availability of the initial data, the purpose of the research and what one wants to show.

Another interesting element to focus on is the destination point chosen at a geographical level, in the case of Lisbon the centroids (or geometric barycentres) of the service locations were used, since using OSM it was not possible to have more precise data; while the methodology used for the case of Turin allowed having a georeferenced point of the address of the entrance of each service (excluding open markets and green areas, since they generally have more accesses).
For both cities, it was decided to omit shops in the analysis, as they are widely present in both Lisbon and Turin and therefore not useful for the research.
The free HQgis Python plugin for QGis, developed on the HERE Routing API (https://developer.here.com/products/routing), was used for the pedestrian accessibility analysis in Turin. Three isochrones were calculated, at distances of 5-, 10- and 15-minutes on foot, from the geometric barycentres of the census tracts. In contrast to the Lisbon research, bicycle accessibility was not considered.
Through this process, it was calculated how many locations of each of the 20 services were included in the isochrones of the census tract, for the 3-time thresholds. The aim was to check the amount of resident population that has access, on foot, to the different services and for different time thresholds.

5.2 Comparison of the two methods applied to the Turin case study

This section compares the two different methodologies by applying them both to the Turin case study. Four services are examined as examples: post offices, libraries, theatres and cinemas and the results obtained are compared.
First of all, the number of locations for each of the 4 chosen destinations is compared, which turns out not to be the same between the open data from the City of Turin's geoportal and the open data from the OpenStreetMap (Table 8).
Following a visual comparison of the locations, it was seen that by overlapping data from the Geoportal and OpenStreetMap, some of them coincide, while others do not (Figure 53 - libraries). The different locations of these services may be because the data from the City of Turin are not updated, but mostly date back to 2014, or that some data obtained from OpenStreetMap are inaccurate.

Table 8. Number of locations of the 4 chosen destinations

	Locations	
	Municipality	OpenStreetMap
Post offices	78	65
Libraries	20	31
Theatres	28	24
Cinemas	26	20

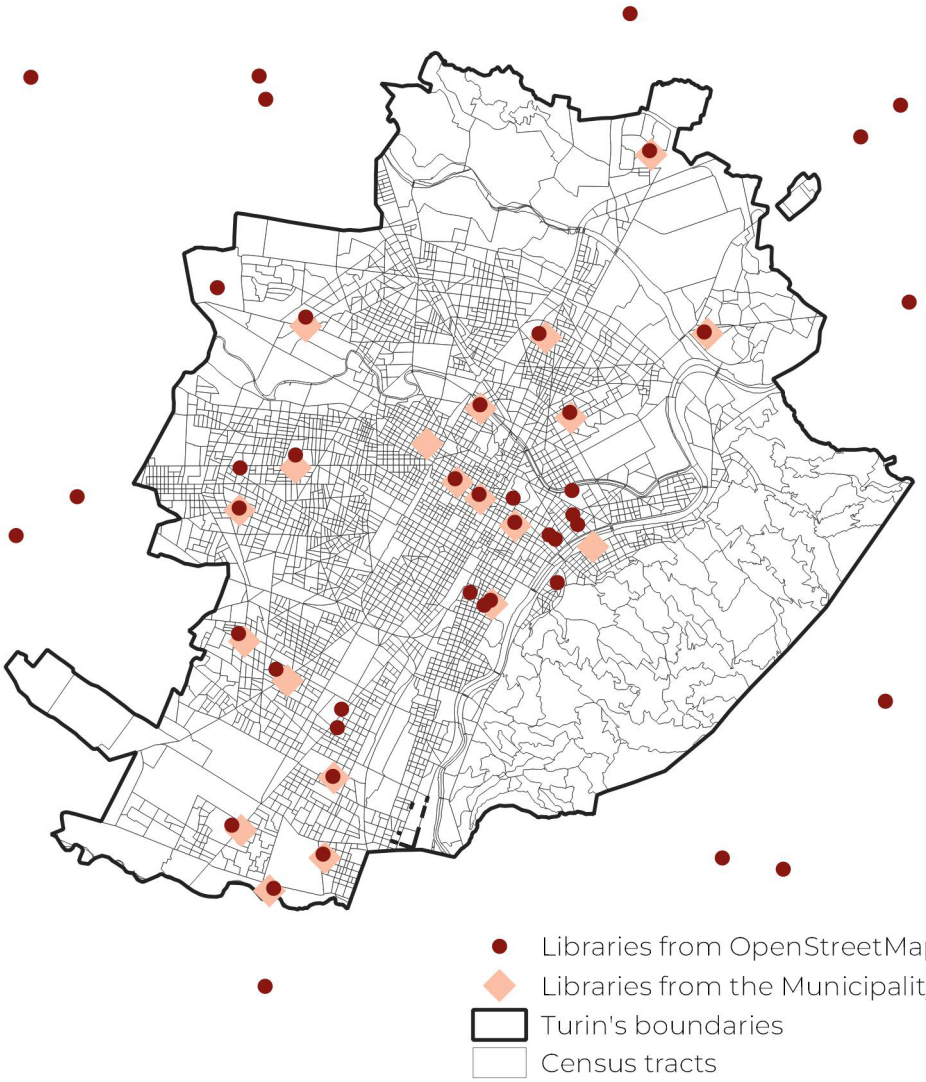


Figure 53: Number of library locations in Turin. In pink are the data obtained from OpenStreetMaptmap, and in blue are those obtained from the geoportal of the municipality of Turin
Source 1: Città di Torino. (2018, july 6). *Geoportale e governo del territorio*. Città Di Torino. http://geoportale.comune.torino.it/web/
Source 2: Câmara Municipal Lisboa. (2023). *Geodados*. https://geodados-cml.hub.arcgis.com/

Table 9 shows the amount of the population that has access within 5-, 10- or 15-minutes of walking time to the 4 selected services, using the 2 different methodologies.
Considering the assumptions, the results of the accessibility analysis conducted using the two methodologies also turn out not to be the same, the biggest differences being observed in theatres and cinemas. Post offices, on the other hand, present quite similar results.
To understand what the actual locations are, we would need updated data on the current situation shared by the City of Turin.

Table 9: Percentage of the population having access to the 4 services within 5-, 10- or 15-minutes walking distance, comparison of the results obtained with the different methodologies

	Municipality			OpenStreetMap		
	1	>1	≥1	1	>1	≥1
			5 minutes			
Post offices	29.9%	2.2%	32.1%	27.2%	1.9%	29.1%
Libraries	6.4%	0.1%	6.4%	6.8%	1.5%	8.3%
Theatres	9.7%	0.6%	10.3%	5.5%	0.7%	6.3%
Cinemas	7.9%	1.6%	9.5%	5.0%	1.5%	6.5%
			10 minutes			
Post offices	47.5%	33.3%	80.8%	40.2%	35.1%	75.3%
Libraries	26.3%	1.1%	27.4%	23.4%	8.4%	31.8%
Theatres	22.8%	6.7%	29.5%	14.0%	5.7%	19.6%
Cinemas	22.5%	5.2%	27.7%	15.7%	5.6%	21.3%
			15 minutes			
Post offices	19.8%	75.2%	95.1%	17.5%	74.0%	91.6%
Libraries	41.9%	8.9%	50.8%	31.2%	23.8%	55.1%
Theatres	35.0%	19.9%	54.8%	26.3%	12.0%	38.4%
Cinemas	33.9%	14.0%	47.8%	26.9%	12.4%	39.3%

5.3 Comparison of Lisbon and Turin results

Although the methodologies applied are different, the results obtained in this thesis, presented in chapter 4.2, followed the model proposed by Professor Staricco in the above-mentioned article (Staricco, 2022).
Firstly, for the Turin case study, the percentage of residents living in census tracts from which it is possible to access one or more locations of each service, within 5-, 10- or 15-minutes of walking distance, was calculated.
Secondly, the percentage of residents who can walk to a certain number of locations for each service within 15-minutes was calculated.
Next, the relationship between the number of locations of each service and the percentage of the population served by that service within the 3-time thresholds was examined.
A sensitivity analysis was then performed to see how the percentage of the population that can access a given service changes with a one-minute change in the 15-minute threshold (thus 14 or 16 minutes).
Finally, the percentage of the population that can access at least some different services within a 5-, 10- or 15-minute walk was calculated.
Comparing the results between Turin and Lisbon, and considering only pedestrian accessibility, some common elements can be found.
The percentage of the population having access to one or more of the services within 5, 10 and 15 minutes of walking time on average is similar: respectively 29.2%, 61.8% and 77.7% for Turin and 26.5%, 57.0% and 76.1% for Lisbon. In both cases, however, the figures vary from service to service.
Regarding entertainment, green areas and sports facilities are accessible to more than half of the population within 5 minutes and to almost the entire population within 15-minutes in both Turin and Lisbon. Theatres and cinemas, on the other hand, are not very accessible in both cities, respectively 48.7% and 27.2% within 15 minutes for Lisbon and 54.8% and 47.8% for Turin. Libraries are also around 50% within 15 minutes in Turin, while in Lisbon the figure is higher (76.0%).
Turin presents good accessibility when looking at data on schools, almost two-thirds of the population can access a seat

for each of the five school grades within 10-minutes, and almost 90% within 15-minutes. In the case of Lisbon, nurseries have not been considered, and there is almost complete coverage within 15-minutes only for first-cycle schools, while for the other school grades, there is a variation between 64% and 83% within the same time frame.

With a few exceptions, for both cities in most cases, more than one location per service can be accessed within a 15-minute time threshold.

For both Lisbon and Turin, a positive trend can be seen when examining the relationship between the number of locations for a given service and the percentage of the population served by this service, with the number of residents served increasing if the number of locations increases (again with some exceptions). At the same time, the spatial distribution of the locations of certain services, which are present in large numbers, could be optimised.

As final thoughts, it can be pointed out that for both approaches, the population was not directly involved in the choice of the services to be analysed. In addition, unlike other studies mentioned in Chapter 1, the accessibility of certain types of service, e.g. shops, restaurants or public transport stops, was not calculated; the research could therefore be extended to other categories.

As far as workplaces are concerned, the issue is more complex, both due to the spread of the practice of smart working and to the fact that not all types of jobs can be located anywhere in the city. This issue will be addressed in more detail in the conclusions.

Another topic that emerged is the physical limits chosen, which fell for both Lisbon and Turin on the administrative boundaries of the cities. While for Lisbon the destinations were calculated within the entire Metropolitan Area, but it was difficult to obtain the exact number of those outside the Lisbon border; for Turin, those just outside the administrative boundaries were not considered. For this reason, the results obtained in census tracts bordering the city and other municipalities may differ slightly.

A final aspect that can be observed is the advantage of using codes written with the Python programming language, compared to using only QGIS software for the analysis, the former makes the process faster.

Chapter 6
Focus on the over 65 age group

The purpose of this chapter is to compare the amount of the population in a certain age group that has access to specific services within 15-minutes, based on the fact that people of different ages may use services differently.
The accessibility of the over-65 population to 9 services (chosen from those analysed above) for each of the 24 *freguesias* in Lisbon is compared, to see where there is an overabundance of users and a shortage of places.
Through a focus on selected neighbourhoods, new locations are then proposed for some of the services found to be lacking, in currently disused areas.
The aim is to demonstrate a possible use of accessibility analysis for administrations to optimise the distribution of services based on the different needs of citizens.

6.1 Elderly population

A major demographic shift is taking place compared to the past, and it is estimated that overall the number of elderly people will tend to increase progressively globally, inversely to the trend of younger age groups, which are declining, and adults, which will tend to be stable. Figure 54 shows world ageing trends from 1950 to 2021, with a projection until 2100, broken down into four age groups: 0-14, 15-24, 25-64, and over 65.
In Europe the phenomenon is even more pronounced, today the over-65 population group represents on average about 20% of the total population (compared to 8% worldwide) and has overtaken the 0-14 and 15-24 age groups. In Figure 55 we can see the European ageing trends, broken down for the same four age groups analysed globally.
Figure 56 shows the percentage of the population over 65 in European countries in 1950, in 2021 and a projection of the year 2100. An increase in the elderly population can be seen in all countries. Portugal ranks third in 2021 (after Italy and Finland) and ninth in the 2100 projection, exceeding the European average value in both cases (Figure 56).
The exponential increase in the elderly population and the overtaking of the total urban population over the rural

population represent a challenge from an economic and social point of view (Arup et al., 2015).

Investigating this age group is also interesting concerning the scientific debate following Covid-19. The pandemic had a significant impact on the physical, mental and social health of the elderly, who represent a vulnerable social class (Mansell et al., 2022). Social isolation and the loss of loved ones have contributed to psychological distress and cognitive and motor dysfunction in this group, particularly for those living in elderly care facilities. Measures to contrast this phenomenon and to address the long-term effects of the pandemic on older people include psychological support, social inclusion and ensuring access to medical care (Mansell et al., 2022).

Urban environments offer benefits to older people, but can also generate insecurity due to social change and urban regeneration. Social and spatial inequalities have been accentuated by the COVID-19 pandemic, with a greater impact on disadvantaged areas and with a prevalence of discrimination and exclusion of older people (Buffel et al., 2021). Structural features of the urban environment, such as lack of accessibility, may cause spatial inequalities and hinder support for the elderly. Elderly people living in disadvantaged and poorer neighbourhoods experience a higher risk during crises (Buffel et al., 2021). There is a need to rethink the shape of cities and communities, paying attention to the needs of different age groups. This includes supporting the most vulnerable, promoting social inclusion, involving older people in urban planning, and ensuring good accessibility of spaces and support services for using digital tools (Buffel et al., 2021).

Often, when designing walkable neighbourhoods, the diversity of abilities and ages of pedestrians is overlooked, creating barriers and exclusions. The elderly, children and people with disabilities are generally the most affected. Standardised rules and lack of universal design are among the reasons that perpetuate non-inclusive environments (Stafford & Baldwin, 2017). Efforts have been made in recent decades to create accessible built environments, but the diversity of abilities within different age groups is often overlooked. Road connectivity, access to services and public transport, safety and attractiveness need to be considered to create inclusive environments. Further research needs to involve a wider and more diverse range of participants through participatory processes to improve neighbourhood design (Stafford & Baldwin, 2017)

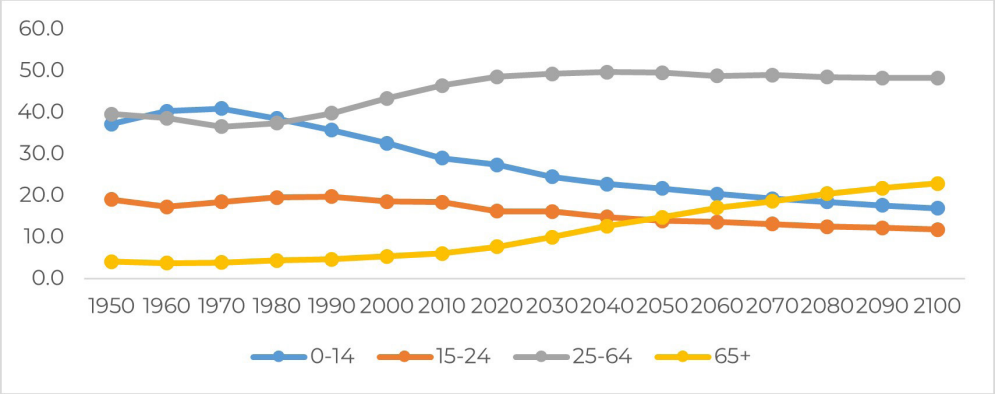


Figure 54. World ageing trends
Source: UN Department of Economic and Social Affairs. (2022). *World Population Prospects 2022: Graphs / Profiles*. United Nations. https://population.un.org/wpp/

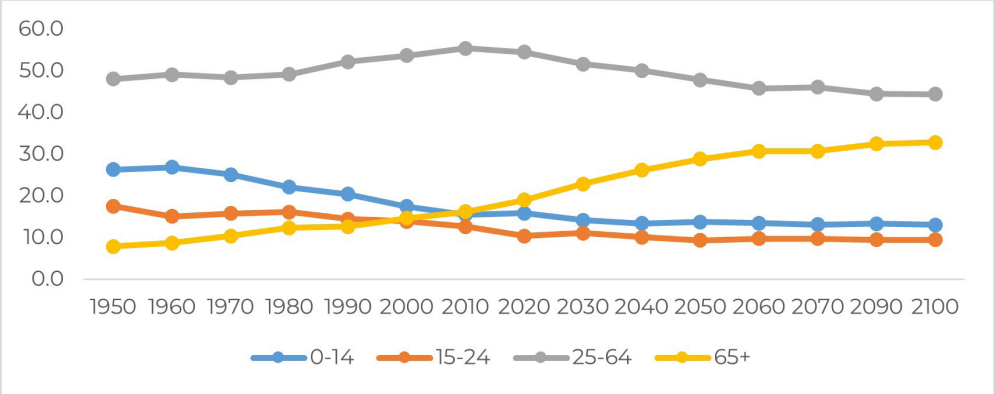


Figure 55. Europe ageing trends
Source: UN Department of Economic and Social Affairs. (2022). *World Population Prospects 2022: Graphs / Profiles*. United Nations. https://population.un.org/wpp/

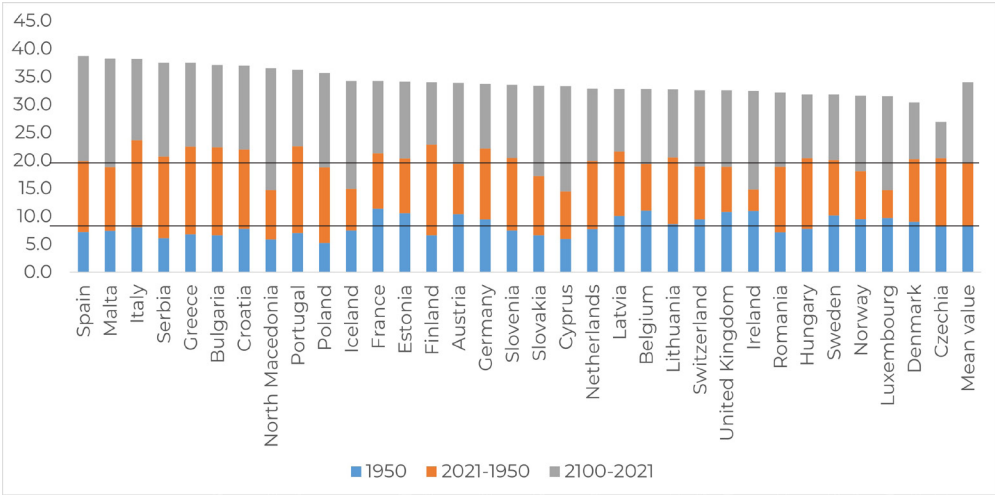


Figure 56. Percentage of population over 65 in Europe in the years 1950, 2021 and 2100
Source: UUN Department of Economic and Social Affairs. (2022). *World Population Prospects 2022: Graphs / Profiles*. United Nations. https://population.un.org/wpp/

6.2 Elderly population in Lisbon

The population over 65 in Lisbon has been continuously increasing since 1960. The document *Plano de Desenvolvimento Social de Lisboa 2017-2020* describes the challenges of an ageing society in Lisbon (Câmara Municipal de Lisboa & Rede Social Lisboa, 2017). It emphasises the importance of longevity policies that value older people and address their specific needs, such as social isolation and difficulties in accessing public spaces and health services. The *Plataforma para a Área do Envelhecimento (PAE) da Rede Social de Lisboa* addresses several problems related to older people, such as social isolation, economic precariousness, accessibility and mental illness (CML & Rede Social Lisboa, 2017). Another related municipal instrument is the *Plano de Desenvolvimento de Saúde e Qualidade de Vida de Lisboa* (PDSQVL), which establishes specific objectives and measures for interventions targeting older people (CML & Rede Social Lisboa, 2017).

Residents over-65 in the city of Lisbon represent a large portion of the population, on average 23.3% of the total, which reflects the country's figure of 22.6%.

On average, individuals between the ages of 0 and 14 represent approximately 13% of the population, those between 15 and 24 10% and those between 25 and 64 54%.

A closer look reveals that the number of inhabitants differs greatly between the different neighbourhoods (called freguesias) of the city, ranging from a minimum of 9658 in Misericordia to a maximum of 46'334 in Lumiar (Figure 57).

The lowest proportions of elderly people are found in the freguesias of Parque das Nacoes (15.2%) and Santa Clara (16.4%), bordering the municipalities of Loures and Odivelas; while the highest proportions are found in the western part of the city, in the freguesias of Ajuda, Belem, Benfica, and Sao Domingos de Benfica, and the two neighbourhoods located in the east, Beato and Olivais, with values between 26% and 30%. The most central areas of the city, on the other hand, present a concentration just below the average, between 20% and 23% (Figure 58).

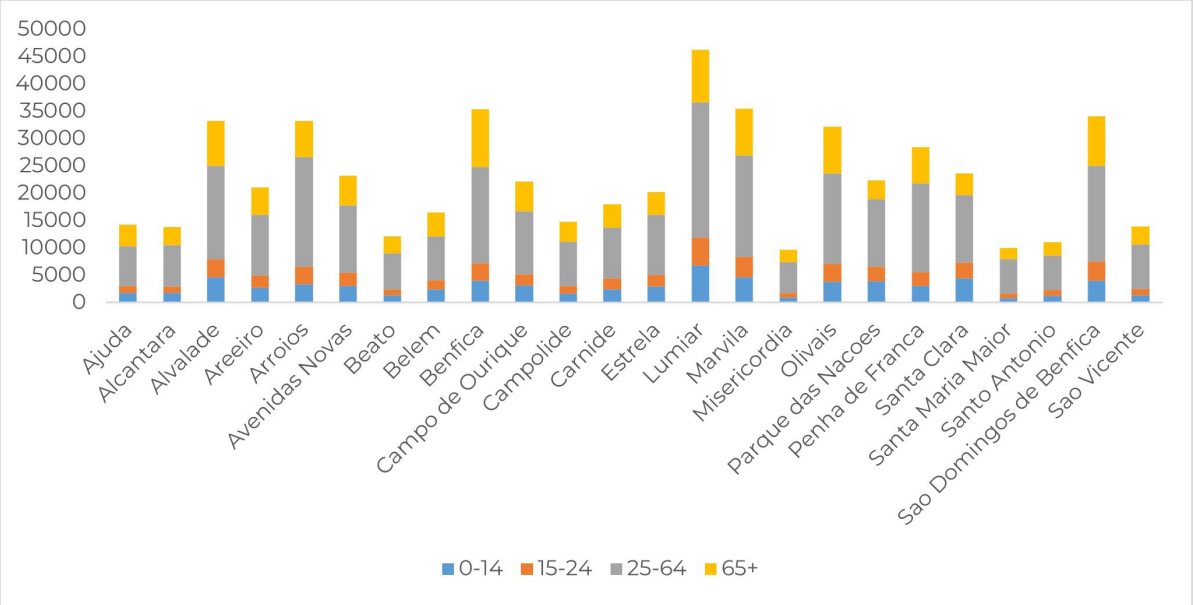


Figure 57. Number of residents of each freguesia by age group
Instituto Nacional de Estatística. (2022, November 23). *Censos - Importação dos principais dados alfanuméricos e geográficos (BGRI e GRID)*. Censos 2021. https://mapas.ine.pt/download/index2021.phtml

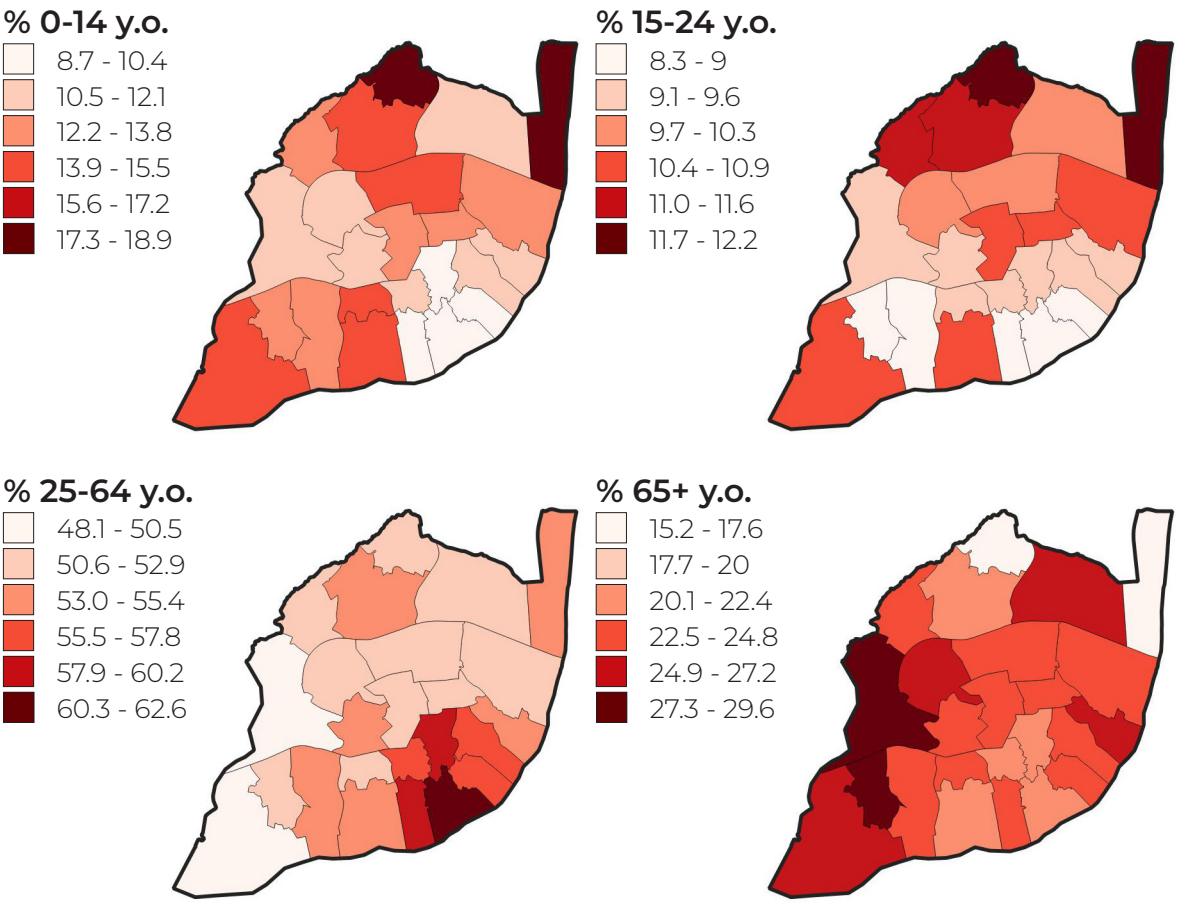


Figure 58. The ratio of residents of a certain population group to the total residents of each district
Source: Instituto Nacional de Estatística. (2022, November 23). *Censos - Importação dos principais dados alfanuméricos e geográficos (BGRI e GRID)*. Censos 2021. https://mapas.ine.pt/download/index2021.phtml

6.3 Accessibility of the elderly population to certain services per freguesia

Once the percentage of the over-65 population out of the total population was determined for each freguesias, the accessibility of certain services (police stations, post offices, open-air markets, social facilities, health centres, banks, libraries, theatres, cinemas) within a 15-minute walk was calculated.
The following services were excluded from the analysis: schools and register offices because they were not considered essential services for the target group; pharmacies, churches, green areas, and sports centres because they were already accessible to almost the entire population evenly across the territory.
Table 10 shows in the first column the percentage of the elderly out of the total percentage of the population in each neighbourhood and in the following columns the percentage of the over-65 population that has access within a 15-minute walk to one or more locations of each of the selected services out of the total over-65 population in each neighbourhood.
The results show that in the "*Zona do Centro Histórico*" the elderly population has access to most of the services considered: in Misericordia, the entire elderly population has access to all services, in Campo de Ourique, Santa Maria Maior and Sao Vicente the over-65 population has good accessibility to all services except cinemas, in Penha de Franca there is good general accessibility except for theatres and cinemas, in Estrela, there is good general accessibility except for cinemas and access to open-air markets is just below average (57% compared to 66%).
In the "*Zona Centro*", accessibility is good overall: in Santo Antonio and in Arroios the accessibility of services for the over 65s is good overall, in Avenidas Novas there is good general accessibility but social facilities are below the average (59% vs. 72%), in Campolide there is good accessibility to police stations, post offices, social facilities, libraries, while it is lacking towards open-air markets, theatres and cinemas, and below average for health centres and banks, in Areeiro there is good general accessibility except for cinemas and libraries are below average (68% out of 80%), in Alvalade accessibility is generally good but police stations are below average (58% out of 79%).
In the "*Zona Ocidental*", the values are overall good in Belem, except for open-air market and cinemas, and social facilities

are below average (59% out of 72%), Ajuda accessibility is overall good except for theatres and cinemas, and police stations are below average (55% out of 79%), in Alcantara the situation is overall good except for social facilities and cinemas.
In the "*Zona Norte*", there is a more uneven situation: in Benfica, the overall accessibility is good except for cinemas and social facilities are below average (54% out of 72%), in Carnide there is poor accessibility to post offices, open-air markets, libraries and cinemas, in Sao Domingo of Benfica there is poor accessibility to police stations, post offices, libraries, theatres and cinemas and social facilities are below average (52% out of 72%), in Lumiar there is poor accessibility to open-air markets, social facilities, theatres and cinemas, in Santa Clara accessibility to services is below average for all 9 considered.
In the "*Zona Oriental*" the situation is similar to the previous one: in Beato police stations, post offices, open-air markets, social facilities and health centres are below average and accessibility is around 50%-60%, while libraries, theatres and cinemas are lacking, in Marvila accessibility is poor for most of the services and good only for libraries, in Olivais there is poor accessibility to open-air markets, social facilities, theatres and cinemas, and police stations and post offices are below average (54% out of 79% and 61% out of 77% respectively), in Parque das Nacoes accessibility is good overall, except for libraries, and the values for police stations and post offices are below average (63% out of 79% and 66% out of 77% respectively).
The results show that the central neighbourhoods are the most served, while the northern and eastern areas present lower accessibility to the 9 chosen services. The most poorly served freguesias for the elderly population are Beato (25.8% over 65), Carnide (23.7%), Lumiar (20.9%), Marvila (24.1%), Olivais (26.6%) and Santa Clara (16.4%), Sao Domingo of Benfica (26.4%).
Cinemas are lacking in most freguesias, and theatres and open-air markets in almost half of the freguesias. Post offices, social facilities and libraries are unevenly distributed throughout the territory.

Table 10. Percentage of over 65s having access to 1 or more locations of each service within a 15-minute walk divided by freguesias

Freguesias	Tot. over 65	Police stations	Post offices	Open-air makets	Social facilities	Health centers
Ajuda	27.4%	54.8%	80.8%	76.8%	84.4%	98.0%
Alcantara	24.1%	85.8%	94.3%	93.7%	32.5%	86.4%
Alvalade	24.7%	58.2%	86.8%	80.0%	81.7%	93.3%
Areeiro	23.9%	74.9%	97.1%	91.0%	93.4%	95.8%
Arroios	20.0%	100.0%	100.0%	97.8%	100.0%	100.0%
Avenidas Novas	23.5%	92.4%	100.0%	97.1%	58.6%	100.0%
Beato	25.8%	62.5%	60.1%	60.1%	64.9%	53.2%
Belem	26.5%	87.7%	70.6%	39.9%	59.2%	98.0%
Benfica	29.6%	80.1%	78.2%	72.3%	53.9%	97.5%
Campo de Ourique	24.5%	96.4%	93.1%	98.1%	93.8%	88.0%
Campolide	24.3%	81.7%	79.8%	42.5%	71.4%	64.3%
Carnide	23.7%	98.9%	27.0%	5.5%	67.1%	89.3%
Estrela	20.7%	100.0%	100.0%	57.1%	100.0%	94.2%
Lumiar	20.9%	85.3%	77.0%	0.0%	33.6%	92.8%
Marvila	24.1%	62.5%	16.0%	6.7%	55.8%	44.8%
Misericordia	23.1%	100.0%	100.0%	100.0%	100.0%	100.0%
Olivais	26.6%	54.1%	61.0%	44.2%	43.9%	96.9%
Parque das Nacoes	15.2%	62.6%	65.7%	64.5%	73.0%	85.0%
Penha de Franca	23.1%	86.9%	88.9%	72.1%	91.3%	100.0%
Santa Clara	16.4%	66.0%	37.6%	0.0%	28.0%	36.9%
Santa Maria Maior	20.2%	100.0%	96.4%	99.3%	100.0%	100.0%
Santo Antonio	21.5%	100.0%	100.0%	98.1%	100.0%	100.0%
Sao Domingos de Benfica	26.4%	7.0%	42.6%	87.3%	51.8%	98.0%
Sao Vicente	23.7%	93.0%	87.6%	100.0%	100.0%	100.0%
Mean value	23.3%	78.8%	76.7%	66.0%	72.4%	88.0%

6.4 New allocation of some services

To demonstrate a possible practical application of the 15-minute city concept for a certain segment of the population (over 65), it was chosen to focus on two types of service (by way of example), whose locations are useful to find in proximity to a large concentration of elderly residents: health centres and open-air markets.
The percentage of the over-65 population that has access to at least one or more of the two chosen service locations within a 15-minute walk was calculated for each freguesia in Lisbon. Cycling accessibility was not considered, both because of the age group chosen and because within 15-minutes the vast majority of neighbourhoods are almost entirely covered.
It was then chosen to focus on the neighbourhoods located in the northeast of the city, as there is a higher percentage of elderly people than the average (except for the Parque das Nacoes neighbourhood) and poor accessibility to the chosen services.
In particular, it is shown how the percentage of the over-65 population that can access these services changes if new locations are allocated where there are now urban voids (abandoned spaces or buildings), for the bordering district of Beato, Marvila Olivais and Parque das Nacoes.
First, urban voids were identified through the use of multiple sources: Google Maps and Google Earth, the urban regeneration project 'ROCK Marvila - Beato' (ROCKLisboa, 2020) and an article dating back to 2017 in which abandoned urban spaces in the eastern part of Lisbon were mapped (Brito-Henriques, 2017).
Concerning neighbourhood health centres, four possible new locations were then selected within the chosen area, taking into account that the average accessibility value for the over-65s in the districts of the city of Lisbon is 88%. According to the analysis carried out, the accessibility of the over-65 population rises from 53% to 100% in Beato, and from 45% to 74% in Marvila. In the neighbouring districts of Olivais and Parque das Nacoes, on the other hand, there is no great change, since the values are already high: 97% and 93% coverage respectively (with starting values of 97% and 85%) (Figure 30).
Open-air markets are on average less accessible in the different neighbourhoods than health centres, averaging 66%. The analysis reveals that by expanding the area with four new locations, the amount of over-65s who have access to this service increases from 60% to 93% in Beato, from 7% to 71% in Marvila, from 44% to 78% in Olivais, and from 65% to 78% in Parque das Nacoes (Figure 31).

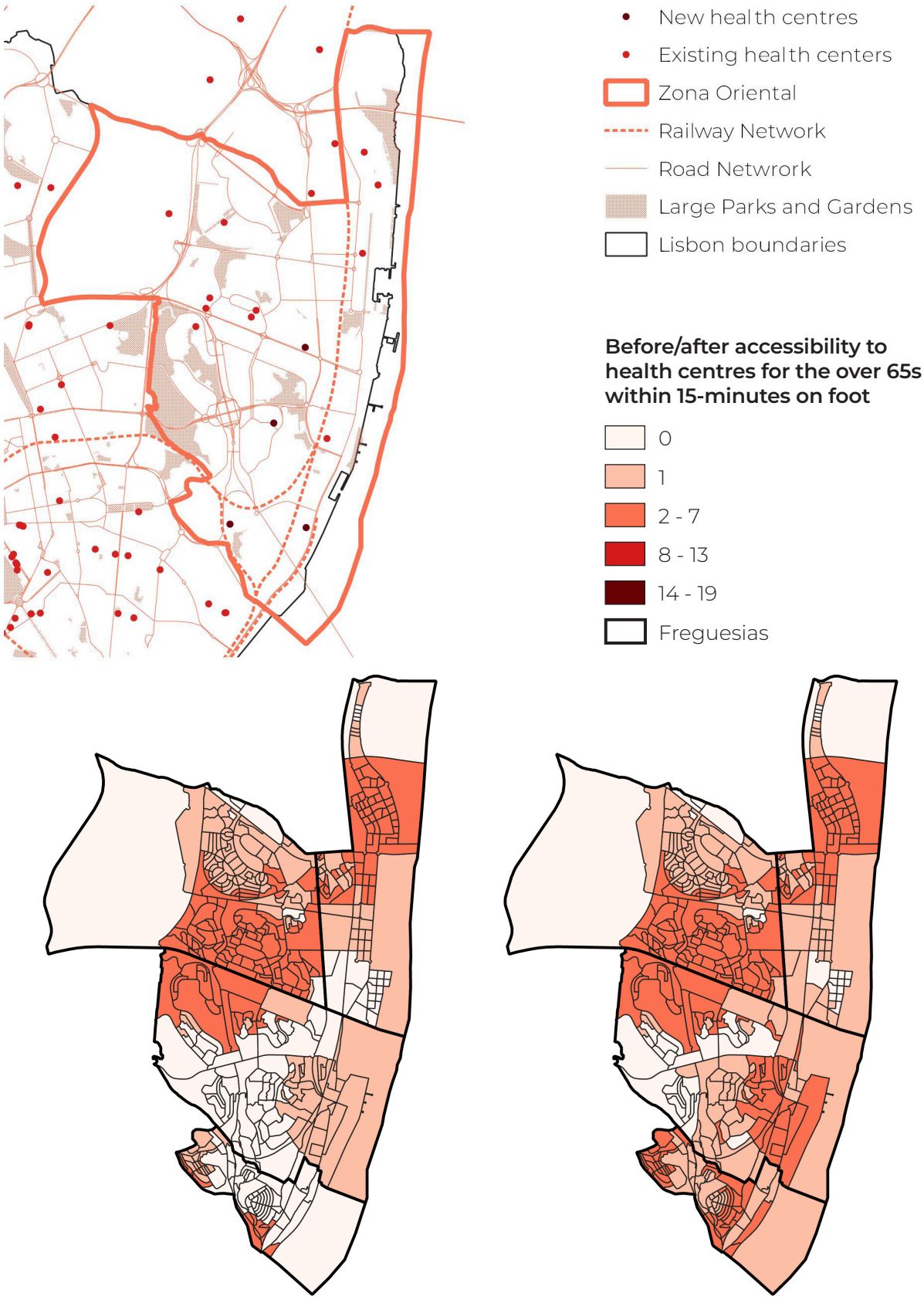


Figure 59. **Before and after accessibility to health centres for the over 65s within 15-minutes on foot**

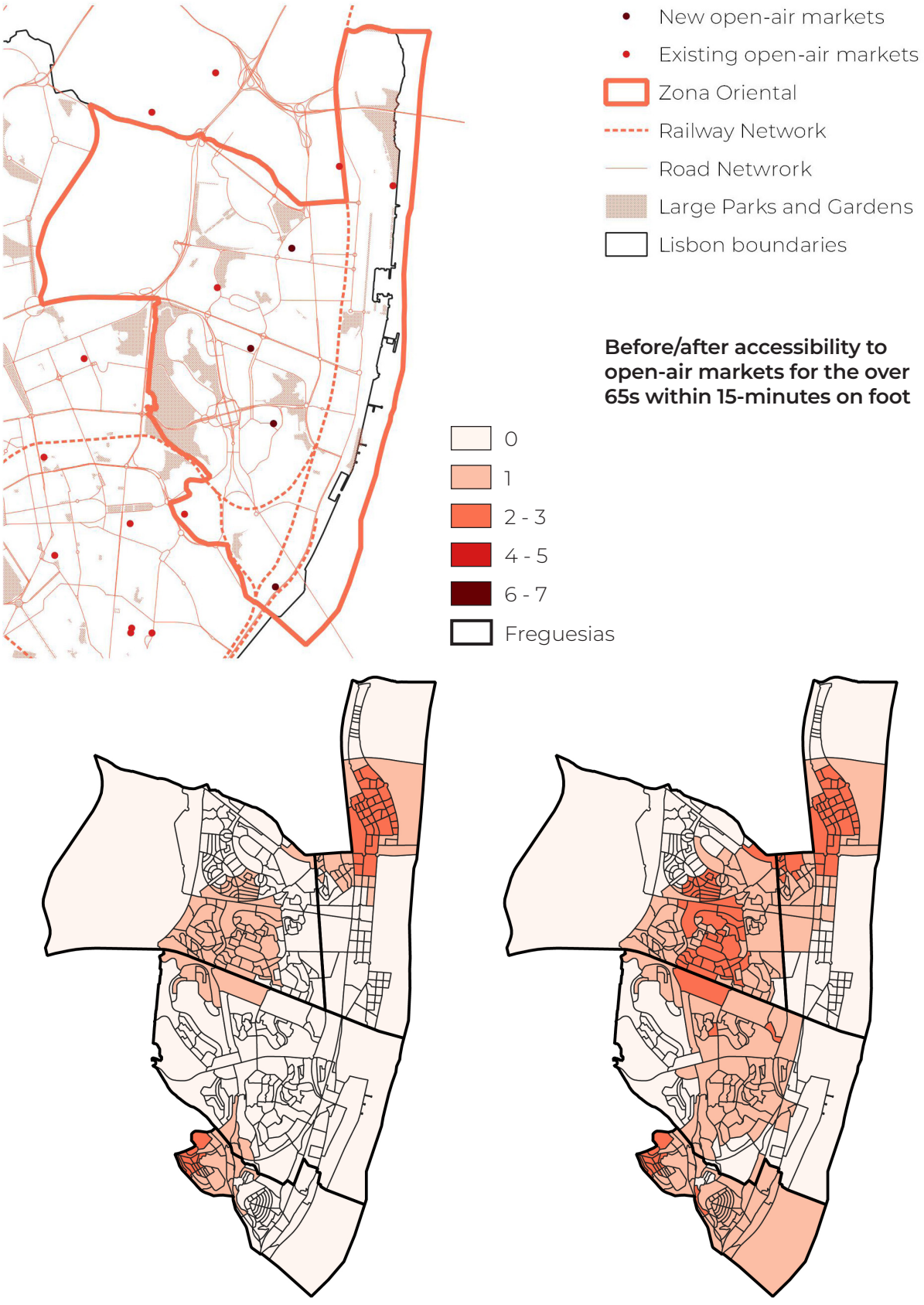


Figure 60. **Before and after accessibility to open-air markets for the over 65s within 15-minutes on foot**

6.5 Final considerations

The analysis carried out in this last chapter is not exhaustive and is intended to act as an example of a possible practical application of the analysis of accessibility according to the 15-Minute City concept, carried out on a given age group.
In this chapter, an average normal walking speed of 4.8 km/h has been used (the same used in chapter 4), but a further analysis could consider different walking times for different age groups, as is indicated in the article by Arup. & al., in which an average speed of 3 km/h is given for pedestrians over 65 and 2 km/h for pedestrians over 80 (2015).
The Stafford & Baldwin publication examines traditional research methods in the design of roads and neighbourhoods for pedestrians. It argues that it would be useful to consider different walking speeds for different abilities and ages, topographical features, climate and the presence of continuous pedestrian routes in the analysis (2017). Future research should take into account the diversity of residents and their walking habits, as well as personal, socio-cultural and socio-economic aspects, including through a participatory approach (Stafford & Baldwin, 2017).
In this case, the over-65s were chosen as the focus of the investigation, but it would also be interesting to analyse the accessibility of schools for the respective age groups attending them or to carry out an analysis based on low/medium/high income, to find out which areas of the city lack certain services concerning the users. The latest geographic data on average income produced by INE is from before 2012 when there was a different administrative division.
For example, if the target to be reached is that 80% of the population should have access to at least one location of the chosen service, different combinations can be tested to see what the best distribution of resources across the territory is.
To obtain a usable result, however, the initial data must be correct; therefore, a mapping of the city's services and urban voids by the municipality itself (rather than data retrieved from OpenStreetMap) would allow for a more accurate final product.
In the case study, the centroids of the census tracts were also used as the origin of the trips, as no building-level population data is available. Having this data available, a more accurate survey could be conducted at this scale.

As a subdivision to compare the results, the administrative one was used, by freguesias. To go into more detail, for example, the document *Uma praca em cada bairro* proposes the development of new squares in the neighbourhoods, through a subdivision of the city into new centralities, but geographical data are not available and would have to be requested from the municipality (CML, 2013).
Finally, the research performed does not take into account road conditions, personal habits of users and other factors, which could alter population choices and alter the results; it should therefore be supplemented with further studies.
The research could also be replicated in other cities by having geographical data on populations belonging to different age groups, with different average incomes, with different physical abilities, etc. This would make it possible to have a targeted analysis for a certain class of people, perhaps first defining through a participatory approach what services are essential at the neighbourhood level for the aforementioned class of analysis.

Conclusions

This thesis investigates an application methodology to operationalise the 15-Minute City concept. The case study of the city of Lisbon is examined and 19 different types of services are selected in order to estimate the amount of population that has access to a given number of locations of each service within three time thresholds, either on foot or by bicycle. The purpose of this process is to understand which areas are more or less served with respect to the catchment area, and thus whether there is an equal distribution of services considered essential at the neighbourhood level, and which services are lacking in the city and which are present in overabundance. This methodology then makes it possible to determine which are the priority areas in which to intervene within the city or which activities to implement, through an intelligent distribution and could be applied to other cities as well.

The 15-Minute City concept was devised by Carlos Moreno (Associate Professor at the Paris Sorbonne Business School) in 2016, but began to receive notoriety after the Covid-19 pandemic, as it responded to the new needs created by the emergency situation (Moreno et al. 2021).

Basically, it is about ensuring that citizens have good accessibility to basic services within a time limit of 15-minutes from their homes, in cases of medium-high density cities, or 30-minutes in cases of low density cities (Moreno et al., 2021). The time limit is not rigid but serves as an indication and should be adapted according to the complexity of the context (Circonomia, 2023). The functions to be considered may also vary from place to place and may be decided, for example, through prior consultation with citizens.

The cardinal principles of this theory are "proximity, density, diversity and digitisation" (Moreno et al., 2021). It is not a completely new theory, as it has common elements with other past planning strategies, including E. Howard's Garden City, C. Perry's Neighbourhood Unit Concept, New Urbanism and others (Khavarian-Garmsir, 2023). The main aspects that characterise them are listed and compared in Chapter 2.

Adopting neighbourhood policies such as the one analysed can lead to the achievement of a number of environmental, economic and social benefits. These include reduced car use, resulting in less air pollution and congestion, as short journeys on

foot or by bicycle are favoured, with consequent effects on well-being and health as well; land protection through optimising the use of resources; revitalisation of city centres through the promotion of local and more accessible commercial activities; increased social interactions due to active travel methods; increased integration between residents due to mixed use and flexibility of housing and services, etc. (Allam et al., 2022).

However, this principle has raised doubts as to whether, put into practice, it could increase phenomena of exclusion and spatial segregation. In reality, the aim of the 15-Minute City is the opposite, i.e. to make access to everyday services more equitable by identifying which areas of the city are less well served, also based on the population living in them (C40 Cities Climate Leadership Group & C40 Knowledge Hub, 2023). To respond to the different needs of citizens, it is necessary to profile who lives within cities and to ensure a percentage of social housing in the neighbourhoods (The Aspen Institute, 2020).

As has already been mentioned, following Covid-19 many cities around the world have decided to adopt the 15-Minute City concept or its variants (e.g. 20-Minute Neighbourhood). In June 2023, the "Global Observatory of Sustainable Proximities" was launched. It gathers the experiences of different cities around the world and academic publications on the topic and aims to serve as a platform for the exchange of information and best practices (C40 Cities Climate Leadership Group, 2023a).

The second chapter presents two studies on cities where the concept has been applied so far and how it has been operationalised. In some cities it has been used as a tool within official urban planning documents, while in others it is used as a strategic tool and in others as a branding tool to make the city more attractive (EIT Urban Mobility & Technical University of Munich., 2022; Gower & Grodach, 2022).

The application methods and services analysed in the cities of Paris, Milan and Ottawa, which have different contexts, sizes and population densities, are then compared. As a result the city of Paris has not included the concept of the 15-Minute City in an official plan, although it is scheduled to do so with the revision of the "*Plan Local d'Urbanisme*", (Ville de Paris, 2022b). Milan included the concept in the document "Milano2020. Adaptation Strategy" and then launched a call in 2022 aimed at small- to medium-sized enterprises, for the implementation of social impact projects that are currently absent or lacking in the different districts (City of Milan, 2022a; City of Milan, 2022b). The

most comprehensive approach turns out to be the one of the City of Ottawa, which includes the concept in the "Official Plan" (City of Ottawa, 2021). It includes an analysis of the accessibility of services within 15-minutes, in correlation with an analysis of the safety and attractiveness of the pedestrian environment. In addition, prior to the diagnostic phase, a consultation phase with citizens is carried out to determine priority axes of intervention (City of Ottawa, 2021).

After examining the 15-Minute City concept and how it is operationalised in some cities, the third chapter focus on the case study examined: the city of Lisbon.

Lisbon is a relatively dense and compact city that is highly dependent on the car, a means used by almost half of the population and the most frequently used means of commuting (INE, 2018). Despite being located on hilly terrain, most of the territory has a gradient of less than 5%, which makes it possible to walk or cycle without problems (Camara Municipal de Lisbooa, 2021). It is also a city historically linked to neighbourhoods, a link that has been partly lost over time (Camara Municipal de Lisboa, 2013). The administration has also included the 15-Minute City concept among the strategies to be adopted, in the document "Grandes Opções do Plano para 2023-2027", which concerns Lisbon's investments for the next four years (Camara Municipal de Lisboa, 2022).

The city of Lisbon was therefore attractive for the analysis of accessibility. The main urban mobility planning instruments that have been active at the national, regional and local level in the last decade have been collected in the chapter 3, in order to understand what strategies have been adopted so far on the topic and how Lisbon's strategies relate to the country's guidelines.

Among the most relevant documents is the "*PAMUS*", adopted by the Area Metropolitana de Lisboa (*AML*) in 2015, in line with the national "Portugal 2020" guidelines (Área Metropolitana de Lisboa, 2019). In this document, a new integrated pricing system is defined for the whole AML, which has contributed to the reduction of vehicular traffic in favour of public transport (Área Metropolitana de Lisboa, 2019). On the other hand, the more recent introduction of the GIRA bike-sharing system and the increase in cycling infrastructure in the city have contributed to the increase in the use of bicycles as a means of transport (Câmara Municipal de Lisboa, 2021), which is currently used by a very low percentage of the population (INE, 2018). Recently,

another measure was taken by the Chamber of Commerce, to integrated the GIRA bike-sharing service for those with an active Navegante monthly pass, making it free for residents (Lisboa Para Pessoas, 2023).

The increase in bicycle use could have a very positive impact on the city of Lisbon. As shown by the results in Chapter 4, in which the percentage of the population that can access 19 different services in the city is analysed, almost all residents already have access within 10 minutes by bicycle to almost all of them. Within 5 minutes, most services are accessible to more than 60% of the population.

Looking at the results for pedestrian accessibility, there is a less homogeneous situation. Within 5 minutes, only a few services (such as pharmacies, green areas and sports facilities) are accessible to more than half of the residents. Within 15 minutes, more than two thirds of the population can access the majority of services. The most lacking are those related to entertainment, such as cinemas and theatres. First cycle schools, churches, pharmacies, banks, green areas and sports facilities appear to be the services accessible to the largest percentages of the population. These services have the largest number of locations, although the range varies widely (from 129 for schools to 707 for green areas).

Concerning the offer of different services within 5 minutes, the situation is rather uneven in the city but there are no areas that predominate over the others. Within 10 minutes a greater concentration begins to emerge in the city's central area, where the historic centre is located. Within 15 minutes in the central area, between 17 and 19 different services can be accessed, while some areas of the city, especially in the east, have up to 11 different services. In general, 30% of the population can choose between 7 different services within 5 minutes, 13 within 10 minutes and 17 within 15 minutes. 60% of the population can reach 4 different services within 5 minutes, 10 within 10 minutes and 14 within 15 minutes.

Through this method, neighbourhoods in need of priority intervention in terms of lack of services can be identified. For example, in the city of Lisbon, bicycle accessibility is overall good and generally better in the central area of the city. With regard to pedestrian accessibility, there is a less uniform situation. Some services (kindergartens, police stations, post offices, open-air markets, social facilities, pharmacies, registry offices, banks, libraries, and cinemas) are less present in the outer areas of the

city. The remaining are less concentrated in the city.
In addition to identifying which areas of the city to intervene in, analysing their accessibility can help to understand which services are more or less present.
A more in-depth analysis could be carried out by assigning these services a different score based on the users they can serve. For example, considering the size of the location examined.
A criticism of the 15-Minute City concept is that it can increase social inequalities, even though its purpose is the opposite. Moreno argues for the importance of social housing to prevent this from happening, e.g., people from a certain social class are forced to move out of their neighbourhood due to rising costs. In addition, the application of this theory should consider the people who live there (Circonomia, 2023). Using disaggregated data, if available, can be a way to profile people of different ages, gender, etc. and provide specific services according to different needs.
In the last chapter, an analysis of the elderly population (over 65) is proposed, which represents a high percentage of the population (23%) (INE, 2022). Using the data obtained from the analysis presented in Chapter 4, the percentage of the elderly population that has access to one or more of the services within 15 minutes was calculated for each of the Lisbon freguesias. Data from each neighbourhood were then compared for the 9 services chosen and it was found that the eastern and western areas are the most disadvantaged. Two services, health centres and open-air markets, were then taken as examples to demonstrate the usefulness of this methodology. New locations of these services were allocated in currently disused areas to show how pedestrian accessibility increases. Through this analysis, it is possible to carry out more tests to see which location is the best from an accessibility point of view.
However, it would be appropriate to use the example of some cities and involve the citizens in the decision-making process to understand which services they prioritise. The city of Ottawa, studied in chapter two, used a participatory process to assign different weights to different activities (City of Ottawa, 2021).
The application of the 15-Minute City concept could also bring benefits in relation to the smart working phenomenon that is expanding especially as a result of Covid-19.
The predominantly monofunctional central business districts could change and work functions could be decentralised and thus be located closer to people's homes (The Aspen Institute,

2020). This principle could be useful for the redistribution and rethinking of services in a mixed land-use perspective and as a function of rethinking the functions of these former office buildings.
The Lisbon case study shows that the city is already partly a 15-Minute City, as most of the services have good accessibility for a large part of the population.
The research could be deepened by comparing the results obtained with those of other cities, as was done in chapter five with the city of Turin (Staricco, 2022), to understand which time limits are most effective for different services. Comparing several cities that are similar to each other (in size, population density, etc.) could help to understand what the minimum accessibility values are with respect to the different services and to set short and long-term objectives for the intent of urban planning policies.

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