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Pétilin Assis Azevedo de Souza
People-centered Urban Measures towards Sustainable Mobility

Universidade do Minho
Escola de Engenharia

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Master's thesis
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Master's thesis developed under supervision of
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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

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People-centered Urban Measures towards Sustainable Mobility

Abstract

The challenges resulting from urbanization growth lead to a continuous need for innovation, regarding a wide approach of sustainable development, when both planning and managing the cities. Once the transportation sector is one with the largest impacts concerning pollutants and greenhouse gases emissions, it is peremptory that governments consider this sector as a target to work in order to achieve the global decarbonization goals set by 2030 Agenda. Therefore, the importance to act in the cities, concerning climate changes, implies a creative capability of interdisciplinary technicians to develop feasible methods to guide governments and citizens towards sustainable solutions of urban planning applied in short periods for long-term changes.

The Municipal Council of Braga, a city in the north of Portugal, launched in 2018 the project BUILD – Braga Urban Innovation Laboratory Demonstrator, which is a Living Lab that intended to promote the city decarbonization. To achieve a behavioral change allowing a transition towards sustainable mobility, through a collaborative and co-created model between interdisciplinary technical team and stakeholders, a diverse range of activities with a people-centered approach was developed. For instance workshops, in which playful participatory processes and participatory mapping were applied. The format of the workshops was defined according to the stakeholder, namely the scholar community, the residents and general city-users of BUILD area. The workshops aimed at the development of an intervention in the public space, while simultaneously spreading and promoting the concepts of sustainable urban mobility and tactical urbanism among the citizens.

Since it is a concrete and achievable solution applied in short periods, tactical urbanism represented an efficient method to develop actions of public participation regarding the city planning. At the same time it highlighted the importance of a cohesive and continuous action of population’s engagement. Furthermore, the promotion of sustainable mobility in a participatory model enables the construction and production of more live and inspiring cities, contributing, simultaneously, to tackle the causes of climate change and to improve urban life quality.

Keywords:

Cities decarbonization; public participation; sustainable urban mobility; tactical urbanism; urban measures

Medidas Urbanísticas Centradas em Pessoas rumo à Mobilidade Sustentável

Resumo

Os desafios resultantes do crescimento da urbanização impulsionam uma contínua necessidade de inovação, tanto no planeamento quanto na gestão das cidades rumo ao desenvolvimento sustentável. Uma vez que o setor de transportes é um dos com maiores impactos nas emissões de poluentes e gases de efeito estufa, é perentório que os governos considerem este setor como um alvo a ser trabalhado de forma a atingir as metas globais de descarbonização estabelecidas pela Agenda 2030. Portanto, para atuar nas cidades, no que diz respeito às mudanças climáticas, é necessário desenvolver métodos viáveis que orientem governos e cidadãos em busca de soluções sustentáveis de planeamento urbano.

A Câmara Municipal de Braga, cidade do norte de Portugal, lançou em 2018 o projeto BUILD - Braga Urban Innovation Laboratory Demonstrator, que é um Living Lab que pretende promover a descarbonização da cidade. Para alcançar uma mudança comportamental que permita uma transição para a mobilidade sustentável, foram desenvolvidas diversas atividades com uma abordagem centrada nas pessoas. Por exemplo, oficinas, nas quais foram aplicados processos participativos lúdicos e mapeamento participativo. O formato das oficinas foi definido de acordo com o público-alvo, nomeadamente a comunidade escolar, os residentes e cidadãos em geral que utilizam a área BUILD. As oficinas visaram o desenvolvimento de uma intervenção no espaço público, ao mesmo tempo em que disseminaram e promoveram os conceitos de mobilidade urbana sustentável e urbanismo tático entre os cidadãos.

Por se tratar de uma solução concreta e realizável, aplicada a curto prazo, o urbanismo tático representou um método eficiente para desenvolver ações de participação pública em relação ao planeamento da cidade. Ao mesmo tempo, destacou a importância de uma ação coesa e contínua de engajamento da população. Além disso, a promoção da mobilidade sustentável em um modelo participativo possibilita a construção e a produção de cidades mais vivas e inspiradoras, contribuindo, simultaneamente, para combater as causas das mudanças climáticas e melhorar a qualidade de vida urbana.

Palavras-chave:

Descarbonização de cidades; medidas urbanísticas; mobilidade urbana sustentável; participação pública; urbanismo tático;

Contents

Glossary

A-S-I – Avoid-Shift-Improve

BUILD – Braga Urban Innovation Laboratory Demonstrator

CCG – Center for Computer Graphics

CECS – Communication and Society Search Center

CMB – Braga Municipal Council

CTAC – Centre for Territory, Environment and Construction

EPOMM – European Platform on Mobility Management

EU – European Union

FUA – Functional Urban Areas

GHG – Greenhouse Gas

INL – International Iberian Nanotechnology Laboratory

IW – Ideas Workshop

LEZs – Low Emission Zones

LIU – Laboratory of Urban Innovation

NUTS – Nomenclature of Territorial Units for Statistics

PER Framework – Analytical Framework of Potential CO_2 Emissions Reduction

PPP – Playful Participatory Process

SCS – Smart City Server

SDGs – Sustainable Development Goals

SMM – Sustainable Mobility Measures

SUMPs – Sustainable Urban Mobility Plans

TUI – Tactical Urbanism Intervention

UM – University of Minho

USA – United States of America

List of Figures

List of Tables

List of Graphics

"Today, only heritage cities uplift and inspire us by the way they are built.

Why not the cities we build now?"

Olga Chepelianskaia

1 Introduction

The global population is still moving from the countryside to the cities, usually seeking better working conditions. According to the United Nations (2018), it was in 2007 that the urban population overcame the countryside population, and in Portugal that happened in 1995. Currently, 55.7% of global population live in urban areas, is expected to rise up to 68.4% by 2050, while in Portugal the expectation lies on 79.3% of urban population (United Nations, 2018). This shift has resulted in levels of urbanization never seen before.

The direct and indirect impacts of urban concentration on the environment is no longer unknown: increased carbon dioxide emission, higher temperatures in cities, higher air pollutants concentration and noise levels, recurring floods or droughts in urban areas, water crises, among other examples (IPCC, 2014).

A reality of several European cities, road traffic is the main source of both air and noise pollution at the local level (Silva & Mendes, 2012), which has an impact both on the environment and on human health, as it will be discussed later. Of all air pollutants in urban areas and surroundings, internal combustion engines represent 60% of the total amount (Petrovic, Bojovic, & Petrovic, 2016). A major problem of large cities is the air pollution caused by fuel combustion in motor vehicles. The combustion in air of hydrocarbon fuel generates carbon dioxide (CO_2) and water (H_2O), at the same time it produces more complex products, such as benzene (C_6H_6), carbon monoxide (CO) and particulate matter (PM), once the combustion motors are not absolutely efficient, neither is the majority of the fuel oxidized (Silva & Mendes, 2012).

Although carbon dioxide (CO_2) is not a toxic gas, it is a greenhouse gas (GHG), similar to water vapor (H_2O), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), chlorofluorocarbons (CFCs) and hydrofluorocarbons (includes HCFCs and HFCs) (IPCC, 2014). A greenhouse gas is a gas that, when in the atmosphere, absorbs and emits part of the infrared radiation, avoiding heat loss from Earth to the space. In turn, CO_2 emission is considered the major considerable cause of global warming and consequent climate change, and at the same time the increase of CO_2 emission is also a consequence of urbanization, as mentioned before (Petrovic et al., 2016).

The case of study of this research is the work developed in the public space under the project Braga Urban Innovation Laboratory Demonstrator (BUILD), a project of Braga Municipal Council (CMB) to promote reductions in carbon emissions. The chosen area of BUILD is located in São Vicente parish, with seven education institutions in the surrounding area.

Through the analysis of current practices of Urban Planning and Mobility, this study intends to discuss the impact of sustainable urban measures, as Tactical Urbanism, on decarbonization process, while simultaneously prototyping an intervention in the public space that aims at the promotion of sustainable and inclusive mobility. The relation between those measures and mobility is their goal to reduce the negative influence of road traffic on the environment.

The prototyped interventions back up the municipalities to assess the impact of specific transformations on urban infrastructure and its acceptance by citizens, while using feasible tools and frameworks to support the development of projects.

Nowadays, the technological equipment, such as electronic sensors that gather information of traffic patterns and air pollution concentrations, provides efficient tools to support the decision-making process of public policies. However, with the environmental impacts of anthropogenic climate change, a change in the habits and in the general paradigm of urban life is urgent towards cities decarbonization. That is possible through adopting sustainable policies and acting directly with the citizens, through public participation.

The importance of acting in the cities, willing to tackle the causes of climate change, implies a creative capability of technicians to develop feasible methods and practical working-tools to guide governments towards sustainable solutions of planning in a short period. Thus, in a future moment, the municipalities are capable of developing and building the city concerning every aspect of sustainability: social, economic, and environmental.

1.1 Objectives

It is important to provide, as a general goal, an assessment of whether the different approaches of urban planning are improving the urban quality of life and the effectiveness of it as a tool to tackle causes of climate change, especially through the implementation of urban interventions with different components such as technology, population and information. In order to achieve a change of the current paradigm of mobility, actions will be developed along with stakeholders to promote sustainable and inclusive urban mobility, prioritizing pedestrians' mode, cycling and public transportation above individual transportation.

Therefore, as its main objective, this research analyses how urban planning deal with public participation, understanding a new urban planning method called Tactical Urbanism and its intervention approach in a small scale of a city, such as neighborhoods. That will provide an opportunity to spread among citizens the knowledge about Tactical Urbanism possibilities. This urbanism focused on action and prototyping is only possible due to a new comprehension of cities as Living Laboratories and intends to enable the understanding of how to cope with sustainable cities development through urban planning.

In addition, the study will further estimate the potential of Tactical Urbanism intervention and Sustainable Mobility measures application on reducing CO_2 emissions at the local level in the study area, throughout the PER Framework. The PER Framework is a calculation method able to support decision-making process while developing the final project of an intervention, and will be deeper presented in the Methods chapter.

1.2 Thesis structure

The present thesis is organized so that the reader is able to understand the concepts in study, the existing problems and the achieved results aimed at answering those problems. Therefore, it is divided into theoretical discussion through literature review and method, as well as practical results, its analysis and conclusions.

- Chapter 1: *Introduction* – In the first chapter the fundaments that support the interest on discussing urban mobility and city decarbonization are presented as well as the objectives that guide the research.
- Chapter 2: *Literature Review* – The second chapter discusses the concepts regarding urban dynamics and practices, and several examples of urban measures to promote sustainable mobility.
- Chapter 3: *Methods* – In the third chapter the methodology of the activities developed to engage the stakeholders and the decision-making tool that can support the implementation of sustainable mobility measures, called PER Framework are described. In addition, the method to assess and validate the considered measures is presented.
- Chapter 4: *Case Study: BUILD - Braga Urban Innovation Laboratory Demonstrator* – The fourth chapter introduces the chosen area of this research, by presenting as well Braga's municipal

project that study the area and supports this thesis. It also presents the results of activities and its validation.

- Chapter 5: *Conclusions* – Finally, the last chapter presents the main conclusions drawn from this master's thesis, as well as potential future evolutions and work.

2 Literature Review

This chapter discusses subjects considered most significant to bring about the understanding of both urban political dynamics and practices. Taken into account in several studies, these subjects concern the need for rapid urban transformation towards cities decarbonization.

2.1 Cities, Mobility and Traffic Pollution

Cities all over the world are continuously expanding and, at the same time, the infrastructure in cities are built to last a long life, some between 50-100 years (Gomez Echeverri, 2018). That means it will have a major influence on urban form and physical structure of several cities, especially concerning investments in buildings, transportation and mobility (Gomez Echeverri, 2018).

Mobility is defined as the ability to move from one place to another and takes place through the appropriation of public spaces. In cities, mobility is also prerequisite for the economy and for the basic freedom of citizens (Caccia, 2015; Costa, Morais Neto, & Bertolde, 2017; Korver, Stemerding, Van Egmond, & Wefering, 2012). At the same time, safe and secure mobility also represents a concern in cities so the European Union (EU) common transport policy made road safety a priority in 2001 (European Union, 2018). Since then, the number of people killed in road accidents decreased, and 25,651 deaths were registered in the EU in 2016, 16.4% less than in 2011 and 53.3% less than in 2001 (European Union, 2018). Those numbers show the impact of public policies on changing the current reality and behaviors related to urban mobility.

Cars remain the dominant mode for passenger transport across the EU, and are responsible for around 12% of total emissions of carbon dioxide (CO_2), the main greenhouse gas (GHG) due to its long lifetime, remaining for years in the atmosphere (European Union, 2018). Globally, economic and population growth continues to be the most important drivers of increases in CO_2 emissions from fossil fuel combustion (European Commission, 2016). The transport sector is responsible for 14% of the total anthropogenic greenhouse gas direct emissions (gigatons of CO_2-equivalent per year, $GtCO_2eq$/year) from economic sectors in 2010 (IPCC, 2014) (Figure 1).

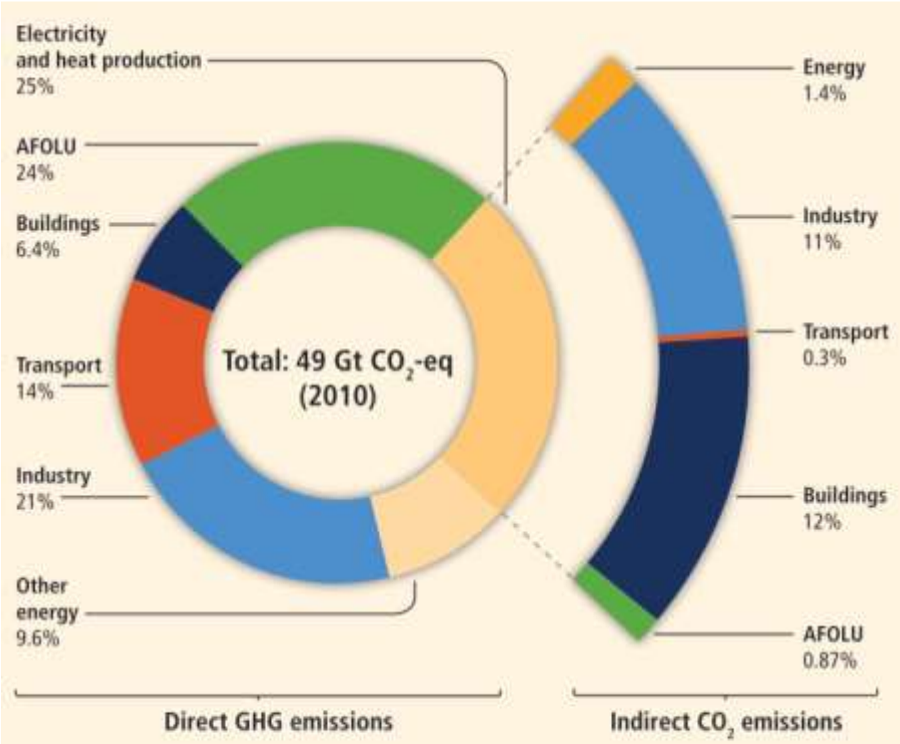


Figure 1: Greenhouse gas emissions by economic sectors in 2010 (Source: IPCC, 2014)

Although overall GHG emissions from transport have not reduced in line with other economic sectors, CO_2 emissions per km for new passenger cars have been continuously falling since 2007 (European Union, 2018). Between 2012 and 2017, emissions per km decreased by 10.4% reaching 118.5 grams of CO_2 emitted per km in 2017 (European Union, 2018). Although mobility does not only mean transportation modes, the impact on environment by choosing between more or less sustainable transportation modes represents a challenge for decarbonization. In order to develop resilient cities able to avoid climate change through its decarbonization, it is necessary to change lifestyles and current mobility patterns that focus on individual transportation (IPCC, 2014).

To improve a city thoughtful planning is required and the planning process of transportation has changed throughout time (Korver et al., 2012). According to Wefering et al. (2014), traditional urban planning was focused on traffic, infrastructure and transportation modals while experts in the domain of traffic engineers planned it. Currently, practices of urban mobility planning focus on people, presenting integrated action to achieve cost-effective solutions in a balanced development of all relevant transport modes, regarding the transition towards cleaner and more sustainable transport modes. At the same time, more interdisciplinary teams began to plan with the involvement of stakeholders.

Due to that, it is possible to see now several policy objectives focused on urban mobility, such as, a sharp reduction in CO_2 emissions to zero in transport to be reached between 2040 and 2050; a sharp reduction in air pollutant emissions; close to zero fatalities in road transport in, depending on the present situation, 20 to 40 years; drastic reducing of congestion in traffic; improvement of urban quality of life in general (Korver et al., 2012). It shows the necessity to act continuously on mobility willing to achieve a more sustainable scenario.

2.2 Health and Environment Effects of Traffic Pollution

A report from IPCC (2014) affirms that human influence was detected in rising temperatures of the atmosphere and the oceans, impacting on global water cycle, reducing snow and ice, and sea level rise in global mean. In the past few decades, the climate changes affected all continents and across the oceans. Irrespective of its cause, the impacts are due to observed climate changes and indicate the sensitivity of natural and human systems to changing climate (IPCC, 2014). It is truly possible that the anthropogenic increase in GHG concentrations and other anthropogenic forces together caused more than half of the observed increase in global average surface temperature from 1951 to 2010 (IPCC, 2014).

The anthropogenic sources of GHG direct emissions commonly existent in the urban environment are originated mainly from traffic and industrial activity (Silva & Mendes, 2012). The major air pollutants in urban area are: nitrogen oxides (NO_x), carbon monoxide (CO), ozone (O_3), particulate matter (PM_{10} and $PM_{2,5}$), and volatile organic compounds (VOCs) such as benzene ($–C_6H_6$) and methane (CH_4) (Silva, 2015).

European cities still face the challenge of air quality. Several urban areas are commonly exceeding the levels of $PM_{2,5}$ and NO_2 concentration allowed by European Union Air Quality Standards (Pisoni, Christidis, Thunis, & Trombetti, 2019). A long-term study linked mortality to traffic intensity on the nearest road to a person's home address (Forehead & Huynh, 2018). The number-one environmental cause of death in Europe is the air pollution. It is responsible for over 400,000 premature deaths per year (European Union, 2018). Moreover, air quality affects everyone; some people, such as children and elderly, are more at risk than others. Because of physiological differences, these people are identified as potentially more susceptible to PM-induced effects than the general population (Sacks et al., 2011). Table 1 shows that every compound leads to specific harmful effects on human health.

Table 1: Harmful effects caused by the main air pollutants (Source: Adapted from Comissão de Coordenação e Desenvolvimento Regional do Norte, 2019)

Human health effects / Pollutant	Eyes and Vision	Lungs and Breathing	Head and Brain	Hearth and Cardiovascular System	Other effects
CO		Suffocating (Avoids blood from receiving oxygen)	Dizziness, drowsiness, headaches	Damages the heart and aggravates heart disease	At high doses, can lead to death
SO_2	Irritation of the mucous membranes of the eyes	Irritation, asthma, emphysema, bronchitis. In children, asthma and pertussis			Decreases resistance to infections
PM	Reduced visibility, irritation of the mucous membranes of the eyes	Chronic bronchitis, respiratory crisis, respiratory irritation		Heart attacks	
NO_2	Reduced visibility	Injuries to the bronchi and pulmonary alveoli			Increases reactivity to natural allergens
O_3	Disturbance	Nasal congestion, asthma, lung damage, cough	Headaches	Chest pains	
BTX					Some are carcinogenic and mutagenic

The objective of the EU in the long term is to achieve air quality levels that do not figure unacceptable impacts and risks to human health and the environment. In this way, the EU acts at various levels with policies aimed at reducing exposure to air pollution by reducing emissions and setting thresholds and target values for air quality (European Union, 2018).

If the rate and magnitude of climate change are limited, it can reduce the overall risks of the impacts of future climate changes. The risks are considerable with temperature increases, even with a rise of 1°C in the mean temperature above pre-industrial temperature levels (IPCC, 2014). With global temperature increasing by 4°C or more, many global risks are high to very high. The risks mentioned by IPCC (2014) include severe and wide-spread impacts on unique and threatened systems, the extinction of many species, large risks to food security and compromised normal human activities, including growing food or working outdoors in some areas for parts of the year, due to the combination of high temperature and humidity.

It remains uncertain the precise levels of climate change that are able to trigger abrupt and irreversible changes remain uncertain. However, the rising temperature also increases the risk associated with crossing those thresholds in the earth system or in interlinked human and natural systems. And so, adaptation and mitigation experience are continuously being accumulated across regions and scales, meanwhile global anthropogenic GHG emissions have continued to increase (IPCC, 2014). Beyond air pollution, the second most significant cause of ill health is noise. Environmental noise causes approximately 16,600 cases of premature deaths per year in Europe (European Union, 2018). Residents living near roads and streets usually mention the traffic noise as the main disturbance and it may cause several health problems, for instance rest hassle, hypertension and psychophysiological manifestations (Silva, 2015).

2.3 Sustainable and Inclusive Urban Mobility as a Goal

The year of 2015 marked a defining period for sustainable development worldwide. World leaders adopted a new global sustainable development framework at the 70th UN General Assembly on 25 September 2015: the 2030 Agenda for Sustainable Development having at its core the Sustainable Development Goals (SDGs). The 2030 Agenda represents a commitment to eradicate poverty and achieve sustainable development by 2030 worldwide. The 17 SDGs (Table 2) and their 169 associated targets are global in nature, universally applicable and interlinked (European Commission, 2016).

Table 2: 17 Sustainable Development Goals from 2030 Agenda (Source: European Commission, 2016)

GOAL	OBJECTIVE	GOAL	OBJECTIVE
	End poverty in all its forms everywhere		End hunger, achieve food security and improved nutrition and promote sustainable agriculture
	Ensure healthy lives and promote well-being for all at all ages		Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
	Achieve gender equality and empower all women and girls		Ensure availability and sustainable management of water and sanitation for all
	Ensure access to affordable, reliable, sustainable and modern energy for all		Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation		Reduce inequality within and among countries
	Make cities and human settlements inclusive, safe, resilient and sustainable		Ensure sustainable consumption and production patterns

Table 2: 17 Sustainable Development Goals from 2030 Agenda (cont.) (Source: European Commission, 2016)

GOAL	OBJECTIVE	GOAL	OBJECTIVE
13 CLIMATE ACTION	Take urgent action to combat climate change and its impacts	14 LIFE BELOW WATER	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15 LIFE ON LAND	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss	16 PEACE, JUSTICE AND STRONG INSTITUTIONS	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17 PARTNERSHIPS FOR THE GOALS	Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development		

In the same year, 2015, the Paris Climate Agreement (COP21), the Addis Ababa Action Agenda, as an integral part of the 2030 Agenda, and the Sendai Framework for Disaster Risk Reduction were also adopted (European Commission, 2016). The 2015 Paris Agreement is a remarkable landmark with great historical significance in the global fight against climate change. The SDG 13 represents the EU's path to a low-carbon and climate resilient economy, through setting an ambitious economy-wide domestic target of reducing GHG emissions in at least 40% by 2030. The target is based on global projections that are in line with the medium term ambition of the Paris Agreement (European Commission, 2016).

Regarding with emphasis and serious concern it is needed to address the remarkable gap between the aggregate effects of parties' mitigation pledges in terms of global annual emissions of GHG by 2020. The pathway consists in holding the increase in the global average temperature to below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels (UNFCCC, 2016).

In turn, the SDG 11 marks the importance to focus on sustainable mobility, with the target of providing access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, by expanding public transport with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons. It also enhances inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.

Following up, several strategic packages arise from European Commission willing to respond in different fields to this global challenge. Highlighting the Energy and Climate Package 2030, Clean Mobility Package and the Clean Energy for All Europeans Package (Portugal Energia, 2019). In 2016, the European Commission presented the Clean Energy Legislative Package for all Europeans with the objective of promoting the energy transition in the decade 2021-2030, that goes towards the goals stablished with the Paris Agreement and, at the same time, economic growth and job creation. This package expects that all Member States prepare and submit to the European Commission a National Energy and Climate Integrated Plan (PNEC) by the 2030 horizon. This plan aims at the establishment by Member States of emission renewable energies, energy efficiency, energy security, internal market and research, innovation and competitiveness, as well as a clear approach to reach them. The PNEC will be the main instrument of energy and climate policy for the decade 2021-2030. Therefore, Portugal presented in January 2019 a national and integrated plan of energy and clime, willing to reach the carbon neutrality in 2050.

IPCC (2014) assures that decarbonizing electricity generation is a key component of cost-effective mitigation strategies in achieving low stabilization levels (of about 450 to about 500 ppm CO_2eq, at least about as likely as not to limit warming to 2°C above pre-industrial levels). Most integrated modelling scenarios shows that decarbonization happens more rapidly in electricity generation than in the industry, buildings and transport sectors (IPCC, 2014). In scenarios reaching 450 ppm CO_2eq concentrations by 2100, global CO_2 emissions from the energy supply sector are projected to decline over the next decade and are characterized by reductions of 90% or more below 2010 levels between 2040 and 2070. Urban infrastructure affects energy through the way it is embedded in its respective contexts in everyday practices, cultures, discourses and institutions. In the transport sector, technical and behavioral mitigation measures for all modes, plus new infrastructure and urban redevelopment investments, could reduce final energy demand significantly below baseline levels (IPCC, 2014).

Urban mobility planning is a challenging and complex task. Planners need to manage many, sometimes conflicting, demands and requirements on the local level and even beyond when it comes to contributing to European climate change and energy efficiency targets. The complexity increases in case of political change and, as it is currently the case in many European countries, severe financial constraints. A Sustainable Urban Mobility Plan (SUMP) contributes to reaching the European climate and energy targets set by EU leaders (Wefering et al., 2014).

A SUMP is a strategic plan designed to fulfill the mobility needs of people and businesses in cities and their surroundings aiming at a better quality of life. It builds on existing planning practices and considers integration, participation, and evaluation principles. A SUMP has several objectives, according to Wefering et al. (2014): to ensure all citizens are offered transport options that enable access to key destinations and services; to improve safety and security; to reduce air and noise pollution, greenhouse gas emissions and energy consumption; as well as to improve the efficiency and cost-effectiveness of the transportation of persons and goods; to contribute to enhancing the attractiveness and quality of the urban environment and urban design for the benefits of citizens, the economy and society as a whole.

Finally, the basic characteristics of a Sustainable Urban Mobility Plan are: Long-term vision and clear implementation plan; Participatory approach; Balanced and integrated development of all transport modes; Horizontal and vertical integration; Assessment of current and future performance; Regular monitoring, reviewing and reporting; and consideration of external costs for all transport modes (Wefering et al., 2014).

2.4 Sustainable Urban Measures of Decarbonization

The awareness of carbon dioxide emission impact on environment and the fact that cities are responsible for over 70% of its emission (Gomez Echeverri, 2018) bring up the discussion that urban challenges must be considered in any mitigation pathway (Grandin, Haarstad, Kjærås, & Bouzarovski, 2018). These urban challenges come from several dimensions such as urban infrastructure, transport, buildings, and waste. This frame presents, at the same time, barriers and opportunities for transition in technical and economic terms (Grandin et al., 2018). Therefore, the mitigation pathway can follow several levels: institutions, behaviours, values, and technologies.

A relational perspective of these dimensions and levels of urban dynamics represents an understanding that the various types of relationships that compose the cities are what truly creates and changes cities.

Looking at how urban development is structured by its political economy and investigating how material forces and non-human agency are moulding urban life, an adaptable relationship between both everyday practices and urban infrastructure becomes evident and results in unequal patterns of urban energy request and well-being, as pointed by Grandin et al. (2018). For example, highly uneven urban mobility – regularly structured along social, gendered and ethnic lines – shows that a given urban structure suits different patterns of everyday life and energy use.

According to Grandin et al. (2018) there is a great potential for carbon dioxide emission mitigation once there are new infrastructures for energy and mobility implemented in urban areas. They also mention recent works on urban energy transition, which show how complex it is to transform urban infrastructures, as they involve more than just implementing new technologies or investing in a public transportation project, for example. There is a social, cultural and political challenge as well.

A report developed by Lopez-Ruiz, Christidis, Demirel, & Kompil (2013) estimated the potential impact of urban measures of sustainable mobility on reducing CO2 emissions at urban level and defined a set of 21 sustainable mobility measures (SMM) divided into seven categories, presented in Table 3. In section 3.4 the report from (Lopez-Ruiz et al., 2013) will be deeper discussed and presented.

Table 3: List of 21 Sustainable Mobility Measures (Source: Adapted from Lopez-Ruiz et al., 2013)

	Public transport services
1	Investment and maintenance, including safety, security and accessibility
2	Public transport coverage (line density, stop density, walking distances between stops) & public transport frequencies
3	Interoperable ticketing and payment systems
4	Taxi services (individual and collective)
5	Dedicated walking and cycling infrastructure investment and maintenance & Bike sharing schemes
	City logistics and distribution
6	Improvement of the efficiency of city logistics by the use of ICT
7	Measures to improve the energy efficiency and environmental performance of vehicles and/or use of alternative modes
	Mobility management
8	Corporate, school and personalized mobility plans (or workplace travel plans)
9	Car sharing & carpooling schemes
10	Telecommunications

Table 3: List of 21 Sustainable Mobility Measures (cont.) (Source: Adapted from Lopez-Ruiz et al., 2013)

Integration of transport modes	
11	Multimodal connection platforms
12	Multimodal travel information provision
13	Park and Ride areas
Road transport	
14	Reallocation of road space to other modes of transport, e.g. dedicated bus lanes
15	Parking management
16	Dynamic traffic management measures
17	Low speed zones
Marketing campaigns and education	
18	Information and marketing campaigns
19	Promotion of eco-driving
Access restriction schemes	
20	Congestion charging zones (area and cordon charging)
21	Low emission zones

Therefore, several measures that change urban infrastructure or mobility patterns are good options to reduce CO_2 emissions, for instance central urban areas closure for vehicles with pedestrian networks (SMM 5); integrated systems of public transportation (SMM 3); implementation of complete streets (SMM 14); scholar mobility plans (SMM 8) and implementation of low emission zones (SMM 21). A few trends of urban measures will be discussed in the next items of section 2.4.

2.4.1 Pedestrianization of Central Areas

In Romania, the city of Oradea developed a project aiming at building better facilities for pedestrians and enhancing the embankments by the Crisul Repede River, as part of a long-term and larger project, (Eltis Editor, 2014). The local administration of Oradea city set up this project in partnership with the Local Waters State Agency, to create pedestrian paths on both banks of the river. The sidewalks and embankments were refurbished with a permeable pavement. Alongside restaurants and terraces on the pedestrian streets light fixtures and attractive benches were installed to create a better-built environment and comfortably welcome the citizens. By sidewalks new bikeways were also installed. This project follows on from the pedestrianization of several streets (Figure 2 and Figure 3) and is expected to foreshadow a larger pedestrian network.

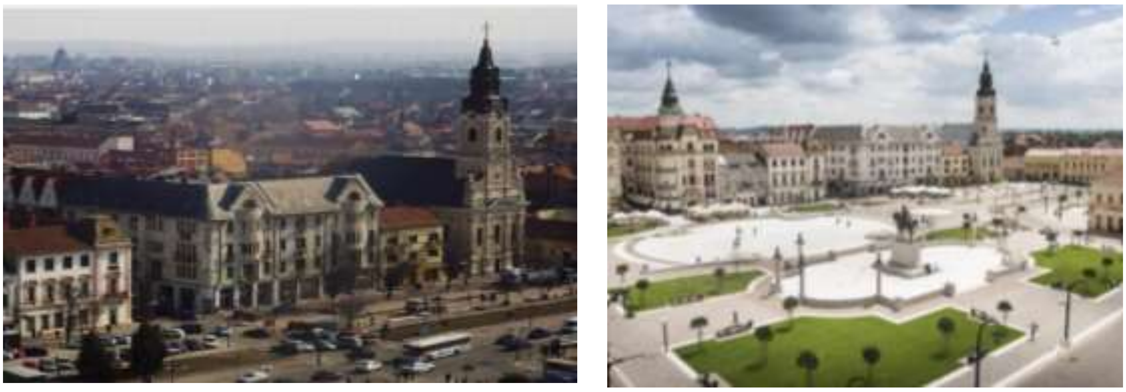


Figure 2: Before and After - Pedestrianization of Unirii Square in Oradea, Romania (Source: Civitas SUMPs UP presentation, 2019)

Figure 3: 2014 and 2018 – Pedestrianization of Vasile Alecsandri Street in Oradea, Romania (Source: Civitas SUMPs UP presentation, 2019)

In Portugal, since 2009, the pedestrian network of Braga's central area has increased, and it certainly helped the reduction of carbon dioxide emission in this specific area. That is because this change in urban infrastructure restricted access for vehicles, in order to guarantee the pedestrian use. From 2009 until 2018 more than 20,000m^2 of the pedestrian network were built, covering a total area of 130,000m^2 (Câmara Municipal de Braga, 2017). The following figures (Figure 4, Figure 5 and Figure 6) show a few examples of this change.

Before Nowadays

Figure 4: Pedestrianization of República Square in Braga, Portugal (Source: Forum Bracare; Igor Cerullo collection, 2018)

2015 2018

Figure 5: Pedestrianization of Liberdade Avenue, in front of Theatro Circo in Braga, Portugal (Sources: Bom dia França; Igor Cerullo collection, 2018)

2009 2017

Figure 6: Pedestrianization of Largo da Senhora a Branca in Braga, Portugal (Sources: Google Maps; Igor Cerullo collection, 2018)

2.4.2 School Mobility Plans

In the past few decades, children's modes of transportation to school have changed, and the number of parents driving their children to school increased, decreasing the students autonomously walking to school. The goal of school mobility plans is to increase accessibility to schools by supporting students to reach their destination in a safe and sustainable way. It can be done through bus services or encouraging car-pooling between parents and teachers (Lopez-Ruiz et al., 2013). It can be offered as personalized services or implemented in schools. There are alternative mobility plans, such as walking buses or bicycle buses to promote more sustainable behaviors in students, concerning safety and environmental issues (Lopez-Ruiz et al., 2013).

In Córdoba, Spain, in the year of 2014 the cost-free pilot-project Walking School Bus started in a public school with a student body of 450 primary students. In the project, professional paid monitors followed the students to and from the school, and the families were provided with a mobile application (Figure 7). The monitors used the same application to collect the children's participation data and provide information on the location of the group. The project lasted 14 weeks.

a) b) c)

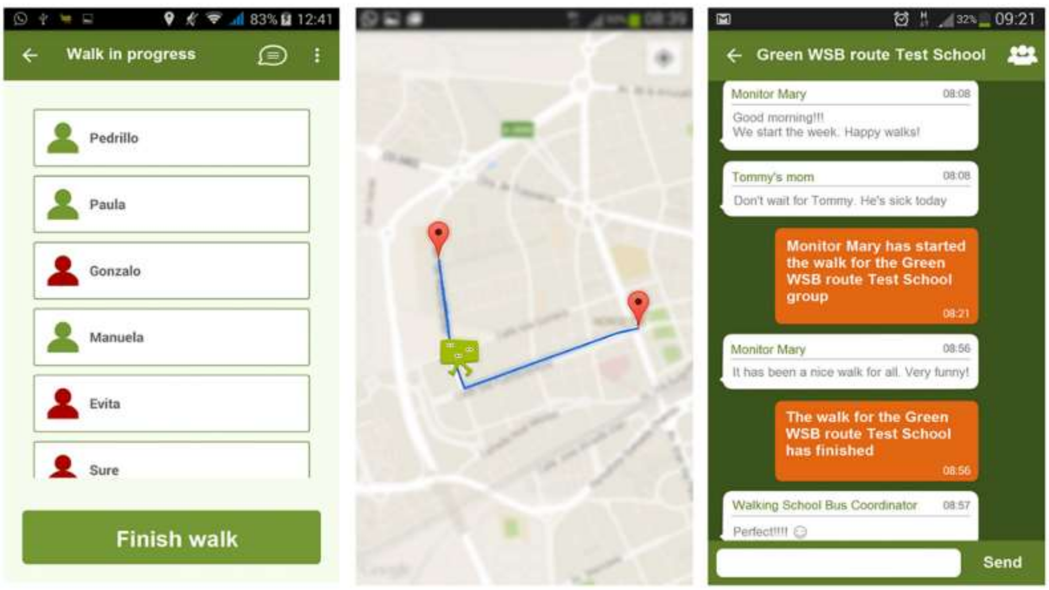


Figure 7: Screenshots of the mobile app: a) List of children, b) Real-time monitoring, c) Notification (Source: P Erez-Martín, Pedr, Martínez-Jim Enez, & Varo-Martínez, 2018)

School Mobility is also a key-factor to properly manage traffic and mobility in the city of Braga (Câmara Municipal de Braga, 2017). Therefore, during the European Week of Mobility in 2017, CMB developed several activities around the city in order to test solutions that could reduce the road traffic in BUILD area; two of them were "PeddyBus" and "SchoolBus" (Figure 8).

The activity "PeddyBus" consisted in a walk ride to schools from specific meeting points. By tracing two ways, adult volunteers followed the children, and a "PeddyBus" group left every 15 minutes. In the first trial, around 10 children joined the activity (Câmara Municipal de Braga, 2017).

At the same time, "SchoolBus" pilot-project was happening, with six bus stops, offering free bus transportation for students from previously selected schools. By the end, it had been used by 700 children (Câmara Municipal de Braga, 2017).

Figure 8: Flyers from activities "PeddyBus" (above) and "SchoolBus" (under). (Source: Provided by CMB, 2019)

2.4.3 Low Emission Zones

Low Emission Zones (LEZs) are areas where the circulation is allowed only to vehicles that follow specific levels of pollutant emission (Panteliadis et al., 2014). LEZs aim to reduce pollution levels and improve air quality in areas where the parameters are not being met, therefore, it encourages the use of cleaner vehicles (Lopez-Ruiz et al., 2013).

In London, if the vehicle does not meet the LEZ (Figure 9) emission standards, it is necessary to pay a daily charge. However, the London government strongly encourage people to make sure their vehicle meets the standards instead. There are no barriers or tollbooths within the LEZ (Figure 10). Instead, cameras read the number plate as the driver is within the LEZ and check it against London's database of registered vehicles. In addition to the existing LEZ emission standards operating across most of Greater London, a phased implementation of stricter emission standards will affect different vehicle types and different geographical areas within London.

Current LEZ emission standards set a limit for how much PM a vehicle may emit. From 26 October 2020, the LEZ emission standards for heavy vehicles will also set a limit for emissions of nitrogen oxides (NOx), which form harmful nitrogen dioxide (NO_2) in the atmosphere. Vehicles need to meet the LEZ emission standards based on vehicle type and the type of emission (Mayor of London, 2019).

Figure 9: ULEZ and LEZ from London (Source: Mayor of London, 2019)

Figure 10: Sign in London's LEZ entrance (Source: Mayor of London, 2019)

In December 2018 the first Scottish LEZ was launched in Glasgow city center (Figure 11). Glasgow's LEZ is phased in and during this first period, it will only apply to local service buses. By 31 December 2022, when the LEZ will have been fully implemented, all vehicles entering the zone (Figure 12) will have to meet specified emission standards (Glasgow City Council, 2019).

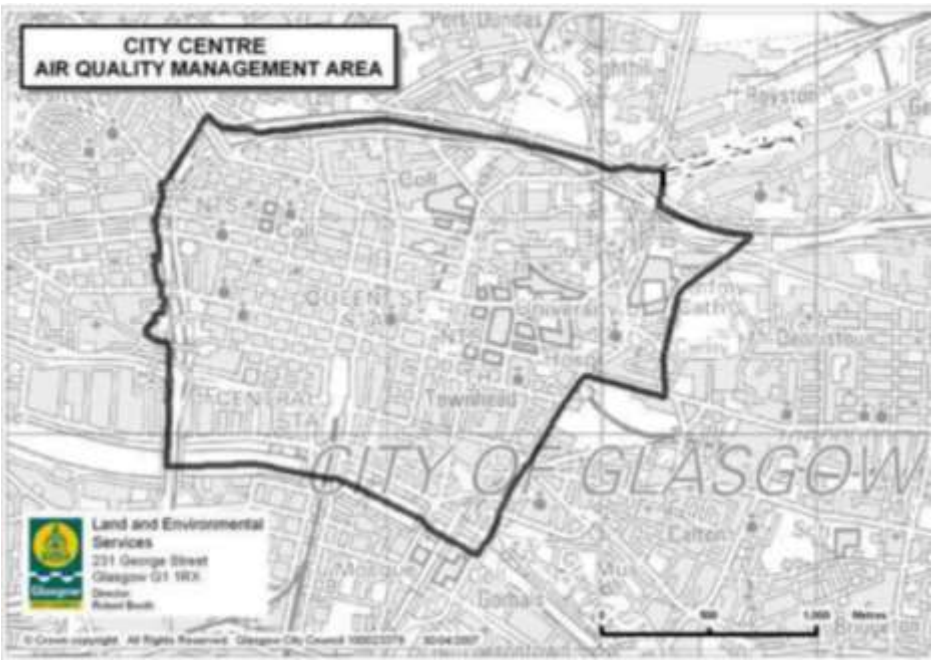


Figure 11: Low Emission Zone from Glasgow (Source: Glasgow City Council, 2019)

Figure 12: Sign in the entrance of Glasgow's LEZ (Source: Glasgow City Council, 2019)

2.5 Tactical Urbanism

Tactical Urbanism is one general term for all different approaches from urban planning focused on action. Also known as DIY Urbanism, Planning-by-doing, urban acupuncture, urban prototyping, as pointed by Lydon (2016), the Tactical Urbanism is an approach in a small scale of a city, such as neighborhoods, to build them using short-term, low-cost, and scalable interventions to catalyze long-term change. The key fact is exactly the focus on long-term changes, otherwise it could be considered a regular urban intervention.

However, this concept will only represent a revolutionary approach, which can change the fundamentalist urban policies, as long as how its application happens is discussed, mainly by governments. The major question about Tactical Urbanism is if it would not only be a benefice approach for the neoliberal urbanism itself, once its implementation is under a neoliberalized rule-regime (Brenner, 2015). Some results of neoliberal urbanisms are to spread commodification across the urban social fabric, to base the collective life of a city through market relations, and to contribute to the enclosure of self-managed urban spaces. That is because those results are based on the market-fundamentalist project through the activation of local public institutions and empowerment of private actors and organizations (Brenner, 2015).

In other words, Tactical Urbanism might involve a challenge to market-fundamentalist urban policy and it can contribute to the ongoing struggle for alternative urbanisms, if it truly considers the humans and the environment upon their potentials and limits of contemporary urbanization.

These new techniques of urban practices can only contribute to change how we currently plan cities if they stop being only technical strategies hired by governments, and start criticizing the current urban planning approach through gathered-shared-creative capacity by which it can coproduce the city. Therefore, alternative urbanisms demand not only new urban spaces, but also new governmental policies that afford public collaboration.

Even though each specific case in the planning process of Tactical Urbanism demands a collaborative and specific design for, it is possible to find so far patterned results among the short-term interventions. Once it involves change to physical design of streets and public spaces, a range of materials can be defined, such as Barrier Elements; Surface Treatments; Street Furniture; Landscaping Elements; Signs; and Programming (Lydon, 2016). Therefore, the next items from section 2.5 will discuss some possibilities of the Tactical Urbanism approach. At the same time, every Tactical Urbanism intervention relates to the Sustainable Mobility Measures presented in the previous section 2.4.

2.5.1 Pedestrian crossings

In the range of surface treatments, pedestrian crossways are a good example. Pedestrian crossings relate to the SMM 5 (Table 3), as it represents an investment or maintenance of dedicated walking infrastructure. A case study from Seattle, United States of America (USA), is the project Community Crosswalks, which allows communities to design especially painted crosswalks to represent their neighborhood. The sponsor organization was United Hood Movement (UHM) and the Pan-African crosswalk began as a guerrilla act (Figure 13). The UHC, an organization supporting colored communities in marginalized neighborhoods, spray-painted four crosswalks with the colors of the Pan-African flag — red, green, and black — in the Central District neighborhood. The unsanctioned project represented UHM's desire to celebrate the black history and culture of the Central District, a rapidly gentrifying neighborhood.

Figure 13: Pan-African crosswalk in Seattle, USA (Source: Lydon, 2016)

The Pan-African crosswalk design was refined through the new program, and the ribbon cutting for the permanent version occurred five months later. The sanctioned project honors the original design, upgrading the spray painted lines with thermoplastic meant to last 3 - 5 years (Figure 14).

Figure 14: Seattle WA's sanctioned crosswalk (Source: Lydon, 2016)

Curb extensions also represent a surface treatment to improve pedestrian crossings (SMM 5). In Portsmouth, USA, a generous curb extension reduces the turn radius and shortens the crossing distance by 20% (Figure 15). A local organization from Portsmouth, USA, called PS21 hired the Street Plans Collaborative to lead the project Islington Street Lab. Street Plans Collaborative is an urban planning, design, and research firm from the USA. The Islington Street Lab project's goal was to engage the community in brainstorming and creating a project in Portsmouth's West End. The Street Plans Collaborative along with PS21, about 20 volunteers, and several city departments worked to install 6 crosswalks; 2 curb extensions (Figure 15); pop-up landscaping using over 3 dozen plants; pavement markings; one parklet and bike corral; and striping to define three new on-street parking spaces. After a successful demonstration, the City decided to move forward with a 30-day pilot to test a number of the project's elements and worked with PS21 to develop a city-citizen demonstration project policy.

Figure 15: Curb extension in Portsmouth, USA (Source: Lydon, 2016)

2.5.2 Interim plazas

A very interesting example of Tactical Urbanism intervention is from New York City (NYC), USA, which brought a one-day plaza to a dangerous six-way intersection on the border of Brooklyn and Queens. With the improvement of pedestrian areas, interim plazas also relate to SMM 5. To gather community feedback for a more robust interim plaza the temporary public space was used. During the demonstration phase, programming the temporary plaza was the key to the project's success. Live music, games, and a mobile library engaged people and activated the space. The mobile library is part of the Uni Project, a non-profit that activates public spaces in NYC. For the interim plaza, barriers to moving traffic and movable tables and chairs constructed which help make the space comfortable for people of all ages (Figure 16).

Figure 16: Demonstration and Interim Design of a Pedestrian Plaza in New York City (Source: Lydon, 2016)

Public spaces, which fill the urban gaps with life, are directly associated with the construction of a city, and influence the relationships that are created within them. A good public space is one that reflects diversity and encourages people to live together effortlessly, creating the necessary conditions for permanence, which invites people to be on the street and increases the city walkability. The vitality of spaces attracts people and what guarantees this vitality is the possibility of enjoying urban spaces in various ways.

2.5.3 Bikeways

Planning bikeways represents both SMM 14 and SMM 5. A bikeway comes in several configurations, from conventional bike lanes, designed with just floor painting, to protected bike lanes with different barriers, such as planters. There are several guides that provide detailed information about bike lanes design, considering a range of bicycle facility types, throughout fast implement low-cost projects that increase ridership and improve safety.

In Burlington, for instance, a multi-exhibit project was part of the effort and design process for Burlington's first citywide walk and bike master plan (Figure 17). It was an approach to test a draft citizen-led demonstration project policy. Street Plans and partners made three bicycle demonstration projects connecting downtown Burlington to the city's Open Streets route in the Old North Center. The project required a curbside parking ahead of installation, followed by a "swapping" of existing bike and parking lanes, achieved with the assistance of many volunteers. The demonstration enabled Burlington occupants to experience the first-ever parking protected lane in Vermont. After its observation in action, the removal of the parking lane and supplanting it with a mountable curb with landscaping turned it into a favored option incorporated into the master plan (Lydon, 2016).

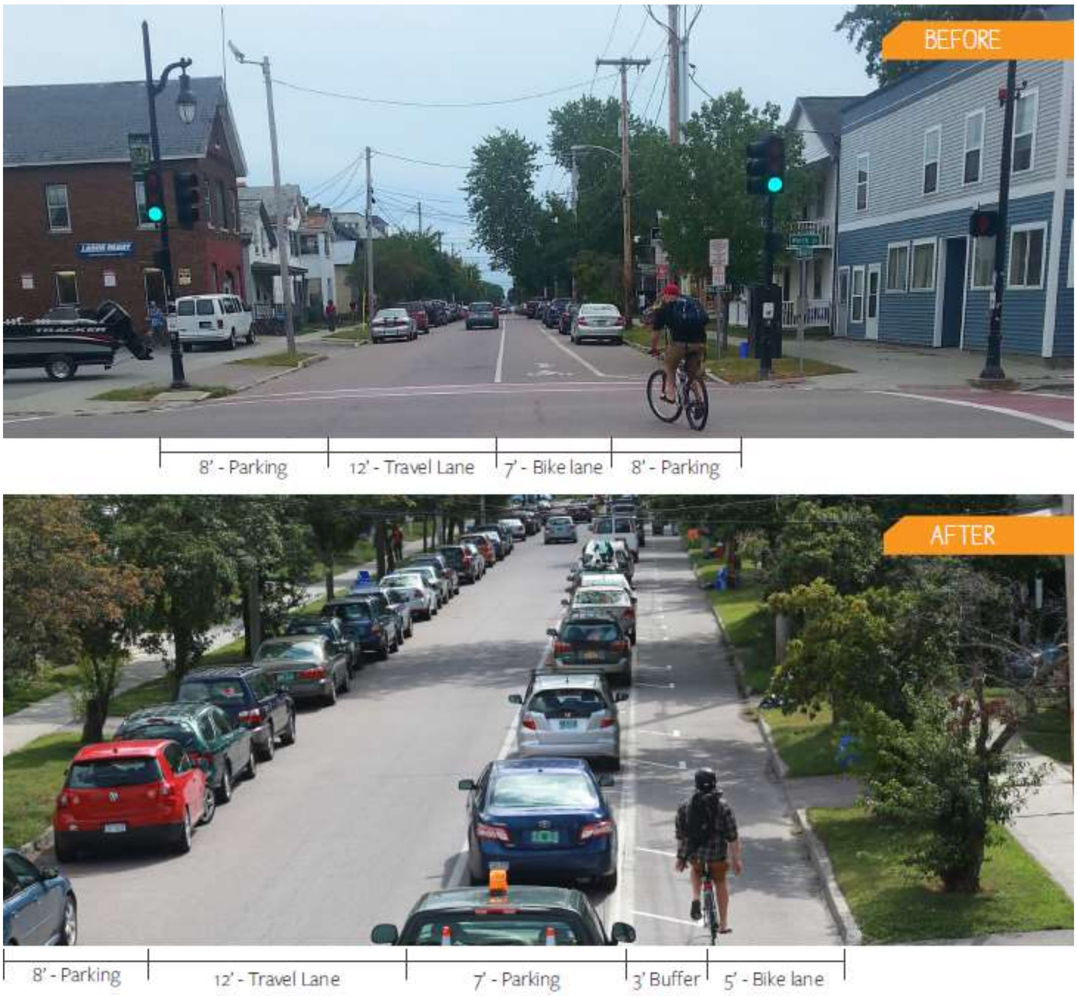


Figure 17: Top: North Winooski Avenue's initial configuration. Bottom: For two days the street was transformed into a parking-protected bikeway (Source: Lydon, 2016)

2.6 Living Labs

European Network of Living Labs (2015) defines the concept of Living Labs as an ecosystem opened to innovation, based on systematic co-creation approach by users that integrates both public and private sectors, focused on research and innovation activities in communities, while it places the citizens themselves at the center of innovation through various approaches, instruments, methods, and tools.

Similar to the Tactical Urbanism approach, as shown before, in practice, living labs also consider the long-term perspective very important in innovative urban planning. Usually, a single project is not truly enough effort to establish and implement in a complex setting, which includes various stakeholders and a permanent operational activity (Santonen, Creazzo, Griffon, Bódi, & Aversano, 2017).

This change from previous top down planning approach towards collaborative and communicative planning is one key-way to bring up sustainable development in urban contexts (Neij, Bulkeley, & McCormick, 2014). A second parallel way towards low carbon urban development, as Neij et al. (2014) affirm, would include developing new forms of innovation and experimentation, creating space for public dialogue and debate over urban futures and their implications for social and environmental justice.

Moreover, Neij et al. (2014) points other few key areas for action. The first one is to ground interests in the low carbon agenda to support and acknowledge urban strategies and targets. The second one is to build up societies of innovation and experimentation at the urban level to cultivate joint effort and the implementation of solutions. The last one is to create dialogue between municipalities, professionals, universities, and communities, through which the challenges and opportunities to negotiate low carbon fates.

It is possible to find at European Network of Living Labs (ENoLL) a range of cities that focus their urban actions on the following themes: Smart cities & regions; Energy; Mobility. In Figure 18, there is specific ENoLL members, presented by maturity of Living Lab (1 to 10 years) with the size of the orange circle.

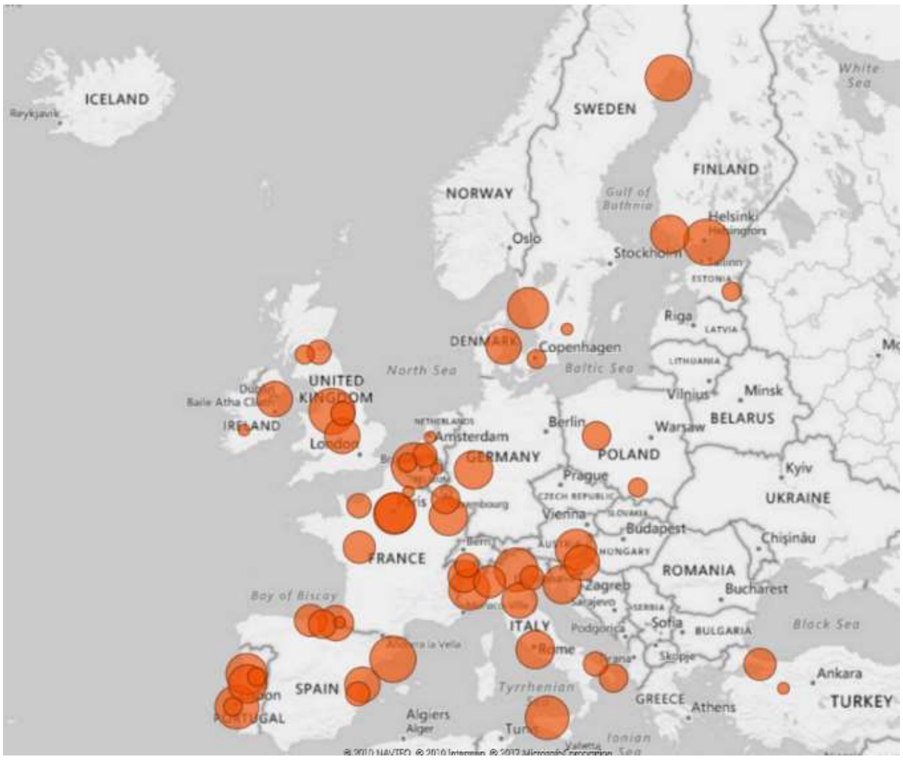


Figure 18: European Network of Living Labs (ENoLL) members focusing on "Smart cities & regions", "Energy" or "Mobility" themes according to maturity (Source: Adapted from Santonen, T. et al, 2017)

The most developed Living Labs are located since 2007 in Ghent (BE), Barcelona (ES), Helsinki (FI), Luleå (SE), Manchester (UK) and Sophia Antipolis (FR). In 2008 Palermo (IT), Trento (IT) and Lisbon (PT) followed on. In 2009, Paris (FR), Turin (IT), Issy-les-Moulineaux, (FR), Águeda, (PT) and Gothenburg (SE) joined in. Besides the members of ENoLL, in Portugal there are also several cities lunching Living Labs projects. Being the case of this study, Braga started formally in 2018 its actions in a specific area of the city. That will be presented in chapter 4.

Other Portuguese examples are Smart City Control Centre of Lagoa, also lunched in 2018; Águeda Cityfy, an application of the city, from 2017; and Amadora Inova, from 2016. For instance, Smart City Control Centre of Lagoa aims to transform the city into the first Smart City of Algarve's region. In the Control Centre, technical professionals are constantly gathering and analyzing the data. They are also responsible to translate it into useful information and then start the solving process throughout an application. The data reports are about water and sanitation facilities; gardens; waste management; infrastructure. Through the technologic innovation, this project brings citizens and municipality closer, sharing the knowledge of the city with more interaction (Computerworld, 2018).

3 Methods

To develop the intervention in the public space considering the tactical urbanism approach, several activities, of both awareness raising and engagement, will be developed along with stakeholders, and are presented in section 3.1. The method of treatment of data gathered in the activities is presented in section 3.2. After receiving the inputs from stakeholders, and by analyzing the treated data, an intervention project will be developed, whose methods are presented in section 3.3. Later, to assess the impact of the urban measures on decarbonization, focused on mobility, an analytical framework of potential CO_2 emissions reductions (PER Framework) will be developed based on the framework of Lopez-Ruiz et al. (2013), which will be later adapted to the chosen area of this study. The PER Framework method, discussed in section 3.4, is expected to work in the future as a decision-making support tool in the phase of the intervention projects development. Finally, to partially assess the impacts of the interventions considered in the intervention project, and consequently, the impacts of the methods here presented, the validation approach is discussed in section 3.5.

3.1 Actions along with Stakeholders

When discussing sustainable urban mobility planning, Wefering, Rupprecht, Bührmann, & Böhler-Baedeker (2014) show that, despite traditional planning focuses on traffic, a sustainable approach focuses on people. Thus, it follows a transparent and participatory approach, bringing citizens and other stakeholders throughout the plan development and implementation process. According to Wefering et al. (2014), participatory planning is mandatory for citizens and stakeholders to take ownership of the Sustainable Urban Mobility Plan and the policies it promotes. The stakeholders engagement, representing the SMM 18, makes public acceptance and support more likely, and usually help to ensure long-term actions' permanence (ITDP Brasil, 2018; Wefering et al., 2014).

To gather specific information different surveys were applied in order to inquire the stakeholders (section 3.1.1). The actions of awareness rising, here presented as mobility games played along with the scholar community, namely the students, are presented in section 3.1.2. Finally, to engage the stakeholders three different formats of activities were developed, according to the stakeholder. The Ideas Workshop was developed with the students (section 3.1.3), and the Focus Groups was developed with their education responsible (section 3.1.4), lastly, the Public Session was developed with the residents and general city-users (section 3.1.5).

3.1.1 Surveys

The main goals of survey applications to enquire people are: to estimate certain absolute quantities; to estimate relative quantities; to describe the population; and to check hypotheses (Ghiglione & Matalon, 2008). Researchers from Communication and Society Search Center (CECS) of University of Minho developed three different surveys to gather information from students from schools in the area, their educational responsible, residents, and city-users, which are the usual people in the area, working or passing by. The gathered information considered commuting characteristics, perception of public space's quality and safety, opinion about city's mobility access and offer, and suggestions to improve mobility in the area of study.

3.1.2 Mobility as a Game

Citizens sometimes can see public participation in urban planning, as pointed by Poplin (2012), as a high investment of time and effort. Therefore, playful participatory process (PPP) in urban planning represents a tool to overcome these barriers and attract citizens to participate, and it includes elements as story-telling, walking, moving, sketching, drawing and games (Poplin, 2012).

In the first action with stakeholders, more specifically to engage the students, they will play two games about the sustainable mobility subject in order to bring up the concept and enlighten the understanding of the impact on environmental of each transportation mode.

3.1.3 Ideas Workshop

The Ideas Workshop (IW) aims to involve the stakeholders in the planning process and was based on the activity developed in Sao Paulo, Brazil, by ITDP Brasil (2018). The IW will be developed with students and the activity will be divided in four moments.

At the beginning, after presenting the activity, the students will be invited to complete a board (Figure 19) with which transportation mode they use to go to school. After that, they will be divided into heterogeneous groups, according to the total number of students during the specific activity.

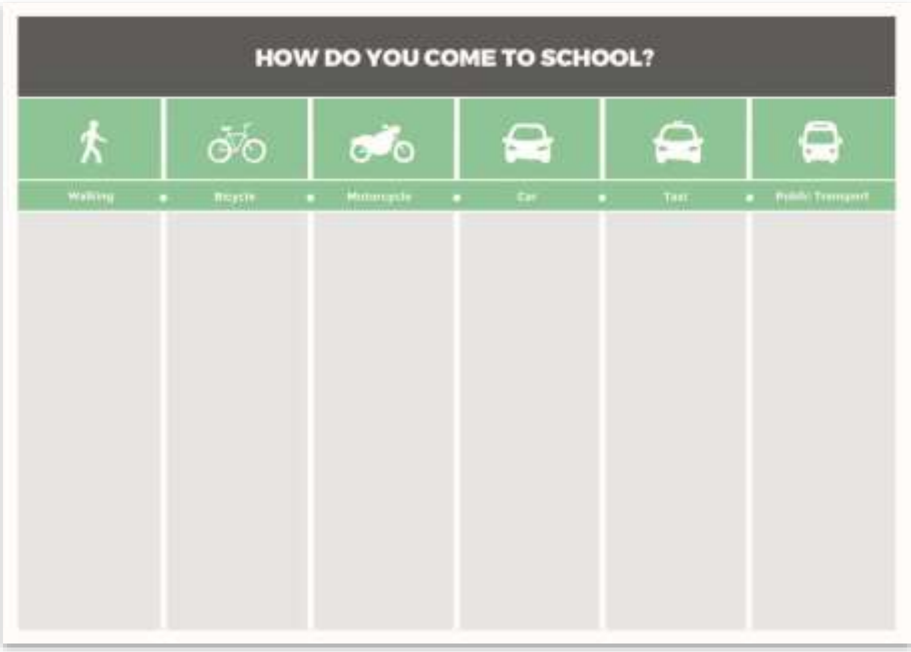


Figure 19: Board "How do you come to school?" (Source: Adapted by BUILD Technical Team from ITDP Brasil, 2018)

To support the later activity of participatory mapping, other methods such as debates, meetings and training enable integration between researchers and community (Araújo, Anjos, & Rocha-Filho, 2017). The training method will be adopted, in which the themes related with the activity will be presented supported by slides presentation.

Besides games, Poplin (2012) affirms that sketching and drawing can be playful activities, and public participation activities can use free-style drawings in the initial, motivational phase, since it seems particularly well suited to capturing objects and situations in a spatial environment, such as geographic space (Poplin, 2012).

Considering that, in the third moment, the students will be invited to draw a mental map of their route from their house to their school. Highlighting important points of reference on their route, as well as the things, people, and landscapes that caught their attention along the way. They will also be asked to indicate the mode of transportation they used.

By the end of the drawing, they will be asked to share their creations with their friends, while the technical team ask how they feel about their journey, what they usually do along the way, if they like it, and if they would like something to be different. After a round, they can mark in red everything they wanted to be different.

The fourth and last moment will be the participatory mapping. When it is not for spatial analysis, participatory mapping is a method able to build more extensive relations and dialogues between researcher and stakeholder (Araújo et al., 2017). At the same time it supports the planning of interventions and is a tool for perception and identification of problems, potentials and possibilities (Araújo et al., 2017). Following the activity developed in Sao Paulo, Brazil, by ITDP Brasil (2018), the goal with the initial maps will be to understand what the city means to the students, and the last map will gather their proposals to change the public space near the school.

3.1.4 Focus Groups

The Focus Groups activities will be developed along with scholar community as well, but in turn it focuses on the educational responsible and will consist in a participatory mapping process supported by a questionnaire. It is important to work along with the educational responsible as well, once they usually are in charge of driving the children to the school. Therefore, the activity will cover aspects such as their perception of the issues regarding mobility in the study area, opinion about public transportation, and patterns of parking area when picking up the children.

3.1.5 Public Session

The Public Session's stakeholders are the residents, tradespeople, and general city-users. The invitation to join the session will be delivered in the residents' mailbox, posters will be distributed among trade's facilities in the area, and via e-mail to the schools and institutions representatives in the study area. The activity's structure will be similar to that of Ideas Workshop. Therefore, in the first moment the activity will be introduced. Then, once the residents were not the initial stakeholders of the awareness raising activity, and to begin the engagement under the mobility thematic, the stakeholders will be invited to play a mobility game. The following phase will be the participatory mapping. By the end, there will be a form available for those who would like to participate in the intervention activity to leave their contact details.

3.2 Gathered data treatment

Considering all the inputs from the activities along with the stakeholders, a final project of Tactical Urbanism Intervention will be developed, whose method will be presented in section 3.3. Thus, several formats of data will be gathered and treated to further analysis. The activities along with stakeholders will be recorded by audio, and transcribed for future content analysis. The transcriptions will be analyzed through content analysis method, in which categories related to the subject of study are created; in this case, sustainable urban mobility.

The children who participated in the Ideas Workshop, drew their mental map. It will be quantified and analyzed how many draws indicated a specific aspect the children wanted to be modified in the city, similar to the content analysis method. The percentage of children that would like to transition towards a more sustainable transportation mode on their commuting to school will also be quantified, and which transportation mode they would consider on using. On the other hand, the percentage of children that enjoy their currently transportation mode (those who did not mention they wanted to change their current transportation mode) will be quantified, and which transportation mode it is. Later, what children who enjoy going by car say about the transformations they would like to see in the city will be analyzed. It aims at understanding their self-awareness on contributing to the environment through adopting sustainable mobility behaviors.

Stakeholders from Ideas Workshops, Focus Groups and Public Session filled the board of which transportation mode they use in their daily travels, and it will allow to calculate the modal distribution of them. In the case of the Focus Groups and Public Session, it also allows to gather their general opinion about using the different transports in Braga, as well as their perception of mobility in general in the city.

In the participatory mapping phase, summary-maps and graphics will be developed considering inputs from the actions along with stakeholders. The summarized information will cover aspects such as safety feelings and reasons; how they use or would like to use the public space; and contributions to tactical urbanism intervention.

3.3 Tactical Urbanism Intervention

For the Tactical Urbanism Intervention a final project will be developed, considering the stakeholders inputs, as mentioned in section 3.2. Through the analysis of the stakeholders' perception and needs, regarding urban mobility issues, the goal of the intervention is going to be the improvement of the city's infrastructure in a way that it promotes sustainable urban mobility.

In this phase it is important to comprehend the needs of the stakeholders and the capabilities of the institutional or political support on effectively building short-term, low-cost, and scalable interventions, paying attention to its impact on catalyzing long-term change. After defining the structure, such as phases of intervention, it is necessary to collect the needed material and to contact the community to involve them by inviting them to participate. It is important to highlight that the success of the intervention relies on the previous steps accomplishments, regarding the awareness-raising and engagement activities. Therefore, it is important to build a strong network between community's stakeholders and political support.

3.4 Analytical Framework of Potential CO_2 Emissions Reduction (PER Framework)

The report developed by Lopez-Ruiz et al. (2013) estimated the potential impact of urban measures of sustainable mobility on reducing CO_2 emissions at urban level and considered each NUTS-3 zone in Europe to set the range of the potential impact. The NUTS classification (Nomenclature of Territorial Units for Statistics) is a hierarchical system to divide the economic territory of the European Union (EU) with different purposes according to its dimension (European Commission, n.d.). In a general way, NUTS-1 is for major socio-economic regions, NUTS-2 for basic regions for the application of regional policies, and NUTS-3 are small regions for specific diagnoses. In Portugal, the division of NUTS-1 is Continent, Azores, and Madeira; NUTS-2 is five regions and two autonomous regions; finally, NUTS-3, concern groups of municipalities.

To quantify the potential range of effects of policy measures on CO_2 emissions for each NUTS-3 zone, Lopez-Ruiz et al. (2013) considered the transport demand and CO_2 estimation results, throughout MODEL-T JRC, for the year 2030. To establish the potential effects of the different policy measures of sustainable mobility, Lopez-Ruiz et al. (2013) carried out an impact assessment regarding different territories in Europe by weighing the experts' scorings according to the current trends in transport behavior that characterize the different cities in Europe present in NUTS-3 regions. Since every city in Europe is different in size, density, population, etc., the effects of measures, according to Lopez-Ruiz et al. (2013), would surely vary from city to city, and so the weighing of the experts' scorings considered that. Therefore, in order to assess how specific measures can affect different European cities, how different urban forms and organizational trends may react to the same set of measures were determined. The urban profiles were analyzed considering aspects of density, accessibility, employment, population and commuting characteristics of each particular zone.

Through an extended literature review, including more than 400 data points of combinations of Sustainable Urban Mobility Plans (SUMPs) measures (five different studies were chosen as sources for gathering data: KONSULT, TRANSPORD, VTPI, EC-Freight and EPOMM), the potential impact of each group of measures was estimated considering three dimensions: Avoid, Shift and Improve (A-S-I) (Lopez-Ruiz et al., 2013). These dimensions concern each measure potential to avoid unsustainable transport practices; to shift from unsustainable to sustainable transport modes; and to improve on current behavior in transport activities. Pisoni, Christidis, Thunis, & Trombetti (2019) affirm that these three dimensions either affect urban mobility in a different way, influencing demand, mode choice or fuel consumption. On the way back, it is affected depending on the urban context, as discussed before.

Therefore, assuming the different characteristics of each NUTS-3 zone and defining seven different urban profiles from most urban to least urban, for each NUTS-3 zone, Lopez-Ruiz et al. (2013) defined the set of 21 sustainable mobility measures (Table 3) considering varying levels of corresponding emissions reductions. These measures do not take into account electric mobility options.

In order to correlate the three coefficients (A-S-I), using the considered aspects of each urban profile, a Random Forest regression model was built. This method is based on the combination of predictive trees (weak classifiers), with each tree constructed from a random selection of samples and variables (Lovatti, Nascimento, Neto, Castro, & Filgueiras, 2019). The advantage of using Random Forests in this application was that it allowed to manage non-linear features and to handle feature interactions (Pisoni et al., 2019).

However, in the matter of measures' presented values by Lopez-Ruiz et al. (2013), one range showed the total for European wide level, and, a second format showed for each country the total value of A-S-I dimensions measures contribution (Appendix A). Therefore it will be necessary to first adapt the values to the country where the study area is located, and then reduce the potential impact values to the dimensions of the chosen area.

3.5 Measures' Impact Validation

It is aimed to validate the measures that are going to be implemented in the case study. The validation method depends on the measures considered, which are presented in section 4.6. The results from measures' impact validation will be later compared with the results obtained through the calculation of potential CO_2 emissions reductions, from PER Framework. This comparison, also presented in section 4.6, will be analyzed to understand if the value is in the range set by PER Framework, or how far it is from minimum or maximum values.

4 Case Study: BUILD - Braga Urban Innovation Laboratory Demonstrator

BUILD – Braga Urban Innovation Laboratory Demonstrator is a Living Lab working towards future city decarbonization that intended to be an urban environment opened to innovation, in which local authorities, companies, the University of Minho (UM), R&D centers, such as International Iberian Nanotechnology Laboratory (INL) and Center for Computer Graphics (CCG), citizens, and local communities act. It applies a collaborative and co-created model, promoting in a real context the development, prototyping, and assessment of new technologies, services, applications, with low environmental impact (Câmara Municipal de Braga, 2017). Fundo Ambiental, a Portuguese fund that aims to support environmental policies to reach sustainable development objectives, finances BUILD project. It contributes to the achievement of national and international objectives and commitments, in particular those related to climate change, water resources, waste management and nature conservation and biodiversity.

The chosen area for BUILD and the present case study is presented in Figure 20 and it is located in the city of Braga, which is in the north of Portugal. Covering an area of about 14 hectares, it represents one of the most recent areas of urban tissue growth in the city, being highly influenced by the mobility dynamics as a result from the proximity to the city center (Câmara Municipal de Braga, 2017). This area stands out for its high traffic level caused by the concentration of seven scholar institutions. The leisure function is fulfilled by two spaces, namely Largo Monte d'Arcos, which integrates parking spaces, living areas and is the entrance to the municipal cemetery, and the public park called Pachancho Children's Park (Figure 21).

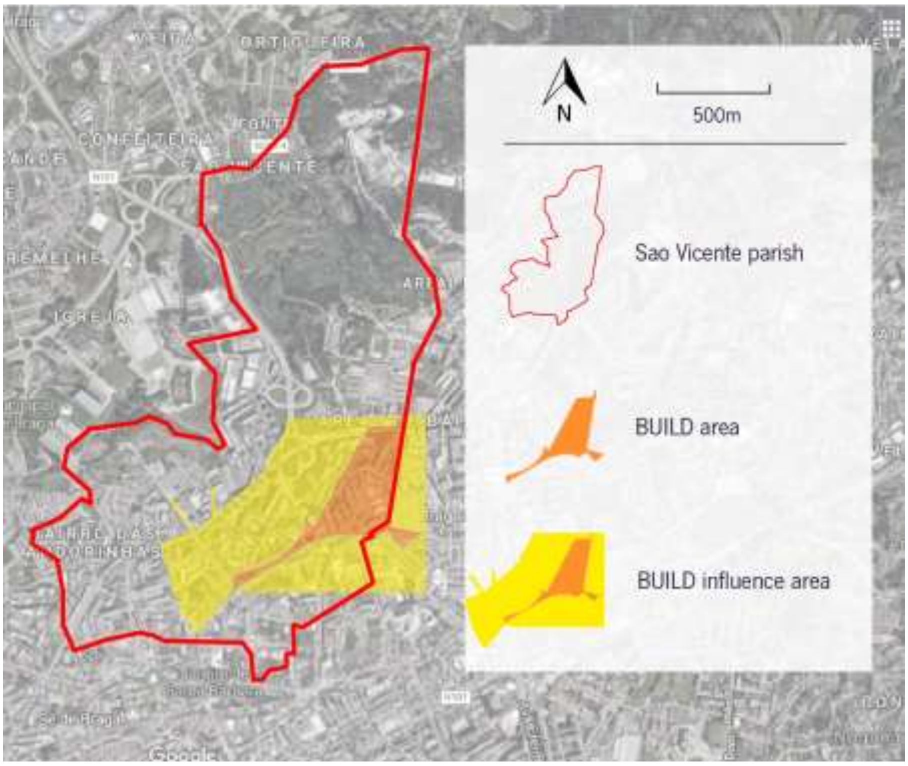


Figure 20: BUILD area and influence area within Sao Vicente parish (Source: Adapted from Google Maps 2019)

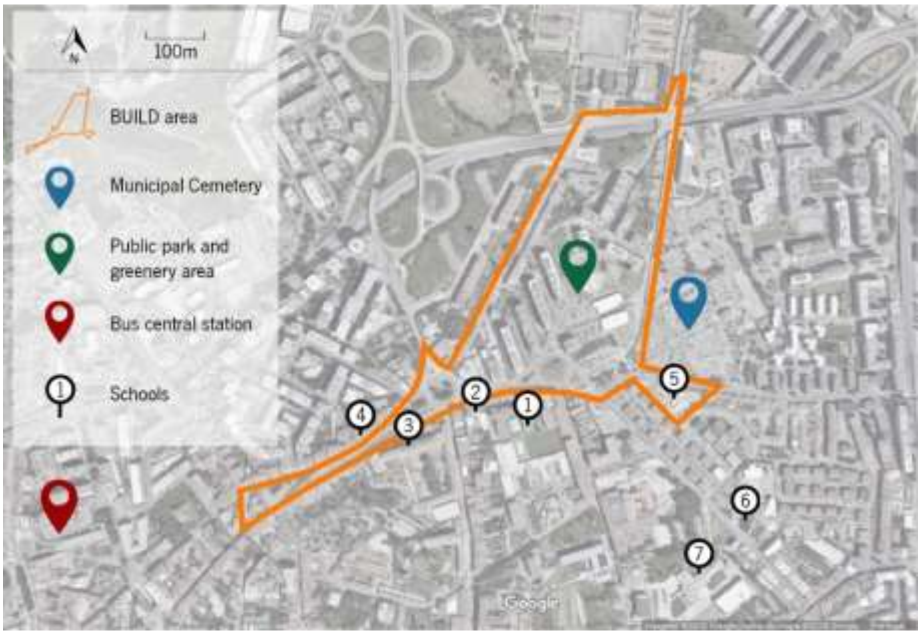


Figure 21: BUILD area and reference points in which 1) Dom Diogo de Sousa School 2) Leonardo Da Vinci School 3) Sá de Miranda School 4) British Institute 5) Enguardas School 6) Teresiano School 7) Francisco Sanches School (Source: Adapted from Google Maps 2019)

As a municipality project based on three strategic approaches as resources sustainability, appreciation of natural resources, public space use, BUILD supports all the main goals of Tactical Urbanism and Living Labs theory. For instance, focusing on citizens, engaging them to work along with the technical professionals, and planning their living surrounding built environment. They also aimed at reducing CO_2 emissions through sustainable development programs and mobility solutions, as well as long-term changes.

The chosen area is a considerable area of traffic congestion and has a problem of lack of inclusive mobility and soft modes, under the existing conditions of urban public life and access, especially regarding abandoned and damaged public spaces. In order to characterize the area, data from Census 2011 (Câmara Municipal de Braga, 2017) was analyzed. It shows that from 75 buildings located in the area only 13 are mixed-use, while 62 are exclusively for residential use, representing that the majority of the people who actually live there use more intensively the public spaces, besides the municipal cemetery. With a population of 990 people and a population density of 9,000 inhabit/km^2, 63.8% of the residents are 25 to 64 years old, followed by 21% from 0 to 13 years old. About education, 33.4% concluded the higher education, followed by 16.4% of junior high school students and 14.8% of high school students (Câmara Municipal de Braga, 2017).

The project BUILD relates technology with the implementation of integrated solutions from several equipment working through the Smart City Server (SCS). These equipment will monitor the traffic and the air quality. With this information, it would be possible, in the future, to quantify and analyze the impact of the interventions from Tactical Urbanism.

The project plan is divided in 7 work packages (WP). The CMB and its institutional partners (UM, INL and CCG) coordinate 7 students from University of Minho and 1 designer supports the work developed by the other students, by producing graphic material for the activities and projects. The students come from different study areas (sociology, architecture, information technology, engineering and education) and work in each WP. These 8 technicians compose the BUILD technical team. The first work package (WP1) intended to manage and follow the work developed. WP2 is about the installation of LIU – Laboratory of Urban Innovation. WP3 aims to develop the SCS that will concentrate all the information gathered from the equipment. WP4 aims to maximize communication and awareness of the population. Under WP5 and 6, interventions will be made on public roads and in the Living Lab area, and are the main focus of this study along with WP4. The interventions aim to promote the change in population's behavior in the matter of mobility to increase the use of soft modes and more sustainable transportation. Finally, the WP7 will ensure the measurement of water and electricity consumption, in order to raise the awareness of citizenship to reduce expenses, to determine consumption patterns, and to detect the occurrence of anomalous situations that may indicate problems in the building.

4.1 Base Scenario and Preliminary Urban Interventions

To use the PER Framework, first it was necessary to determine a base scenario of CO_2 emissions calculated from a traffic base scenario. Researchers from Centre for Territory, Environment and Construction (CTAC) of University of Minho determined the traffic base scenario (CTAC, 2018) considered in the calculation according to a vehicles counting in the BUILD area from 2017. The counting was made during the rush period, in the morning from 7.45am to 9.45am and in the afternoon from 5.15pm to 7.15pm. Later, following each street type, classified as high or local traffic, a traffic per hour for both light vehicles and heavy vehicles was determined. Then, by varying the counted traffic in the rush hours, the daily traffic (24h) was obtained. For this purpose, the traffic of a type road network was considered, named as "Masters", which aims to estimate and extrapolate traffic volumes at different times of the day to hourly points. After setting a daily traffic, it was divided into periods of the day (daytime, evening and night) (Table 4). The heavy vehicle traffic along the same periods was also divided.

Table 4: Reference periods. (Source: CTAC, 2018)

Reference periods	Time interval (h)
Daytime	7h00 – 20h00
Evening	20h00 – 23h00
Night	23h00 – 7h00

For the roundabouts, the CTAC researchers divided them in sections, thus considering sections between the various entrances and/or consecutive exits of the roundabouts. After determining the number of vehicles passing on each section, the vehicle traffic was calculated for each period of the day (daytime, evening and night), as well as the percentage of heavy vehicles over those periods. Finally, considering the daily traffic on each section of the roundabout, they established an average of the various sections, resulting in a traffic of the roundabout. The CTAC's researchers applied the method of calculating CO_2 emissions considering the BUILD influence area (Figure 20) that aggregates BUILD area and surrounding area.

The calculation took into account the characteristics of the Braga vehicle fleet, presented in Table 5 with the percentages of light and heavy vehicles depending on the type of fuel in the year 2017 in Portugal (CTAC, 2018). In light vehicles, there is a clear predominance of diesel oil (64.1%). For heavy vehicles, the percentage of petrol is nearly insignificant, since diesel represents 99.49% of these vehicles. In this way, CTAC researchers considered all heavy vehicles as diesel vehicles (100%). On the other hand, Table 6 indicates the amount of fuel per kilometer (kg/km) consumed by the different types of vehicles (light and heavy vehicles), depending on the type of fuel used.

Table 5: Percentage of light and heavy vehicles by type of fuel. (Source: CTAC, 2018)

Type of Fuel	Light vehicle [%]	Heavy vehicle [%]
Diesel	64,1	99,49
Petrol	34,5	0,03
LPG	0,8	0,05
Other	0,6	0,43

Table 6: Quantity of fuel consumed by type of vehicle. (Source: CTAC, 2018)

Type of vehicle	Fuel consumption [kg/km]
Diesel light vehicle	0,07
Petrol light vehicle	0,06
Diesel heavy vehicle	0,24

Then, based on the number of vehicles circulating in the intervention area, CTAC researchers calculated the CO_2 emissions in the area through the following Equation 1:

Equation 1: Daily CO_2 emissions by vehicles (Source: CTAC, 2018)

$$CO2_{\text{emissions}}(kgCO2eq) = \Sigma(N_{i,j} \times D_{i,j} \times EF_{i,j})$$

In which:

Ni,j – Number of vehicles of category "i" with fuel "j"

Di,j – Distance traveled by vehicles of category "i" with fuel "j" (km)

EFi,j – Emission factor of category "i" vehicles with "j" fuel ($kgCO_2eq/km$)

The conversion factors for calculating the greenhouse gas emissions considered the parameters set by the British Government (CTAC, 2018; DEFRA, 2017). Once the characteristics of the vehicles fleet from Braga are unknown, CTAC researchers adopted medium values to choose the emission factors for the different types of vehicles and for the different types of fuel, resulting in the values presented in Table 7.

Table 7: Emission factors for different types of vehicles and different types of fuel (Source: CTAC (2018); DEFRA (2017))

Vehicles type	Fuel type	Emission Factor ($kgCO_2eq/km$)
Cars	Diesel	0.17887
	Petrol	0.18568
	LPG	0.20105
Heavy vehicles	Diesel	0.9339
Bus	Diesel	1.2194
Motorcycles	Petrol	0.11662

Then, the CTAC's researchers calculated the annual CO_2 emissions ($kgCO_2eq$/year) in all the road networks belonging to the BUILD influence area considering, due to the large concentration of educational institutions, buses account for 80% of heavy vehicles. Table 8 shows the base scenario of annual CO_2 emissions in the BUILD influence area for each type of vehicle, with a global CO_2 emission of 12,594.15 $tonCO_2eq$/year.

Table 8: Annual CO_2 emissions per vehicle type for the BUILD influence area ($tonCO_2eq$/year). (Source: CTAC, 2018)

Car (Diesel)	Car (Petrol)	Heavy vehicles (Diesel)	BUS
5,839.87	3,262.81	561.07	2,930.39

However, since September 2018 the CMB implemented a few preliminary interventions. For instance, a Kiss & Go parking in front of several schools, such as Dom Diogo de Sousa School and Leonardo Da Vinci School (Figure 22), a bus lane (SMM 14) also in front of those two schools (Figure 23), and an intervention to convert a regular crosswalk into a smart crosswalk (SMM 5). The crosswalk has a system of intelligent lightening in the pavement and was implemented in front of Dom Diogo de Sousa School (Figure 24).

Figure 22: Kiss & Go parking implemented in September 2018 (Source: Author, 2019)

Before After

Figure 23: Bus lane implemented in September 2018 (Source: Google Street View, 2019; Author, 2019)

Before After

Figure 24: Intervention on pedestrian crossing in front of Dom Diogo de Sousa School, converting it into a Smart Crosswalk in March 2019 (Source: M. Silva collection, 2019)

Besides those physical interventions and after the success of the pilot-project, the School Bus was implemented for the school year of 2018/2019 (Figure 25). In September 2018, the School Bus began and in January 2019, there were 410 children inscribed. The main goal of the project is to improve safety, accessibility and mobility in the inner city center, especially near the schools. In addition, it will improve air quality through contributing to the decarbonization, as well as presenting an alternative to private transportation.

By implementing four bus stops, a service available at 07h45 for public schools and at 08h20 for private schools that effectively transport 128 children in a trip of 15 minutes, which translates into a reduction of about 200 commuting journeys in the inner city center.

Figure 25: School Bus operating in 2019 (Source: M. Silva collection, 2019)

The interventions of bus lane (SMM 14) and smart crosswalk (SMM 5), as well as the School Bus project (SMM 8) were considered in the calculation of potential CO_2 emissions reductions of BUILD Influence Area presented in section 4.6. However, from these preliminary interventions, only the impact of the School Bus project was validated and the validation calculation will also be present in section 4.6.

Furthermore, the implementation of environmental sensors in the BUILD area in March 2019 will allow to have more accurate data. Through the analysis of the information gathered from these sensors it will be possible to assess the decarbonization trends in the area. However, in the present moment, there is not enough historical information to do so.

4.2 Actions along with Stakeholders

The actions to promote Inclusive and Sustainable Mobility represented by SMM 18 (Table 3), were developed with different stakeholders of the BUILD area. Once the pilot-intervention planned was in the surrounding area of two schools of BUILD area (Figure 26), Leonardo Da Vinci School and Dom Diogo de Sousa School, the activities developed were along with students and educational responsible from both schools, as well as with the residents and city-users from BUILD area. Therefore, the following sections present those actions, for instance, surveys, games to discuss sustainable mobility, and different formats of the workshops applied, such as ideas workshop, focus groups, and public session.

Figure 26: Schools' surrounding area and intervention area (Source: Google Maps, 2019)

4.2.1 Surveys

The specific theme of each survey, developed by CECS' researches, was Scholar Transportation and School Bus measure, Residents profile, and General population opinion about the pedestrian crosswalk. The survey about Scholar Transportation and School Bus was applied to understand if and why the educational responsible feels the school surrounding area is safe, commuting characteristics to pick up the children from the school, why they choose that transportation mode, if they consider that the School Bus changed the mobility patterns from their family, etc.

The survey of residents' profile (Appendix B), the only one analyzed to the purposes of this study, allowed the development of a sociological diagnosis and the resident population's characterization in relation to the main dimensions of the project: energy consumption, time use, mobility practices, perceptions, and suggestions. Around 600 surveys was distributed in the resident's mailboxes, and five coffee places in the area were available to receive the completed surveys (Figure 27). The stakeholders could also fill it online, through a link available in the survey. As mentioned, the "yes" answers for the question number 27 (Appendix B) were analyzed and quantified: "In order to contribute to the environment in the city of Braga, would you be willing to switch to less polluting modes of transport?". The answer options were yes, no, maybe. The calculation is presented in section 4.6.

Figure 27: Letters with the surveys and boxes to return completed surveys (Source: BUILD Technical Team, 2019)

Finally, the last survey focused in a specific pedestrian crosswalk aimed to assess the behavior of pedestrians while crossing the street in front of the Dom Diogo de Sousa School, and their opinion about the crosswalk safety and suggestions to improve it. This specific crosswalk was selected because it was improved in February 2019 and converted into a smart crosswalk, as an intervention of BUILD project. After its improvement, a final survey gathered the general population's opinion about that intervention.

4.2.2 Mobility as a Game

In the first game, 40 students from Leonardo Da Vinci first year class divided into groups of 10 should hank from more sustainable to less sustainable six transportation modes for its impact on environment considered per person. The transportation modes (Figure 28) were walking, bicycle, metro, bus, motorcycle and car. The first group (yellow cards) firstly placed the car in the third position of more sustainable mode, and after seeing the results of the other students, they discussed again and changed their answer to the correct one (Figure 29).

Figure 28: Transportation modes cards (Source: BUILD Technical Team, 2019)

A)  B) 

Figure 29: A) Last group organizing the cards the yellow group placed the car in third position of more sustainable mode B) Yellow group correcting themselves by comparing with the other groups' answers (Source: BUILD Technical Team, 2019)

The "Big Mobility" (Figure 30) was another game played to engage both the students and residents. The students, divided into groups of 15 to 20 children, played by answering questions about mobility from a dice (Figure 31). This activity developed during classes pauses aimed also to publicize the School Bus project (see section 2.4.2). CMB firstly developed this game in 2017, during the European Mobility Week, and the BUILD Technical Team adapted it for its activities. In total about 100 students participated in the Mobility Games.

Figure 30: One question from the dice of "The Big Mobility" game (Source: Provided by CMB, 2019)

Figure 31: Children playing The Big Mobility game (Source: BUILD Technical Team, 2019)

4.2.3 Ideas Workshop

The students who participated in the IW were from two different schools, 22 students of 4^{th} class from Leonardo Da Vinci School and both 4^{th} class and art students from Dom Diogo de Sousa School, with 109 and 11 students respectively, totalizing 3 Ideas Workshop applied and 142 students involved.

After filling the board of which transportation mode they use to commute to school (Figure 32), they were divided into groups of around 10-40 students. Once the students were separated into groups, the BUILD technical team presented the activity and the themes that were going to be discussed, for instance the concept of Urban Mobility, Sustainable Urban Mobility, and Tactical Urbanism as a tool to positively change the public space (Figure 33).

Figure 32: Students filling the board of transportation mode (Author: BUILD Technical Team, 2019)

Figure 33: Presentation of Sustainable Urban Mobility and Tactical Urbanism in Dom Diogo de Sousa School (Source: BUILD Technical Team, 2019)

The students were then invited to draw their route from home to school, indicating the mode of transportation they used and afterwards they marked in red everything they wanted to be different (Figure 34 and Figure 35. Other examples in Appendix C). The art students, in turn, developed the mental map of the surrounding area of the school, showing their perception of the mobility in the area.

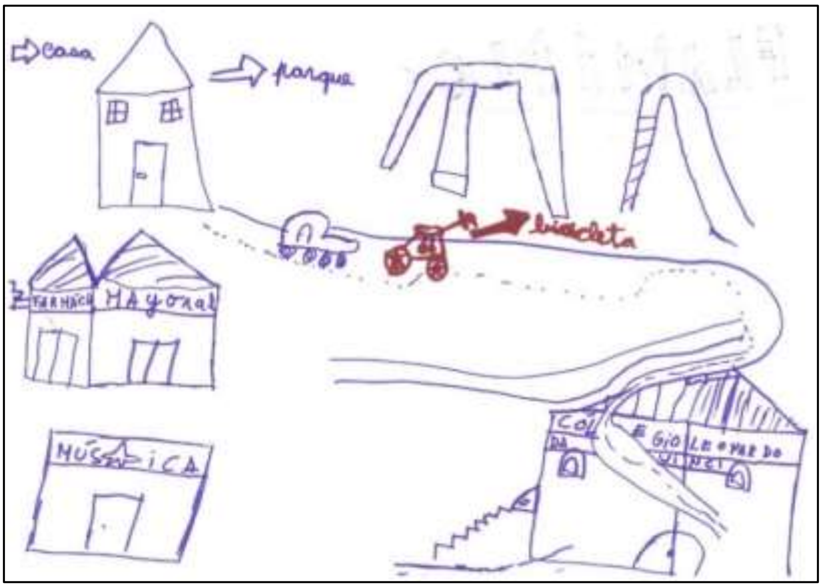


Figure 34: Mental map drawn by a child, who wanted to go by bicycle to school (in dark red), during the Ideas Workshop (Source: Anonymous Student from Ideas Workshop, 2019)

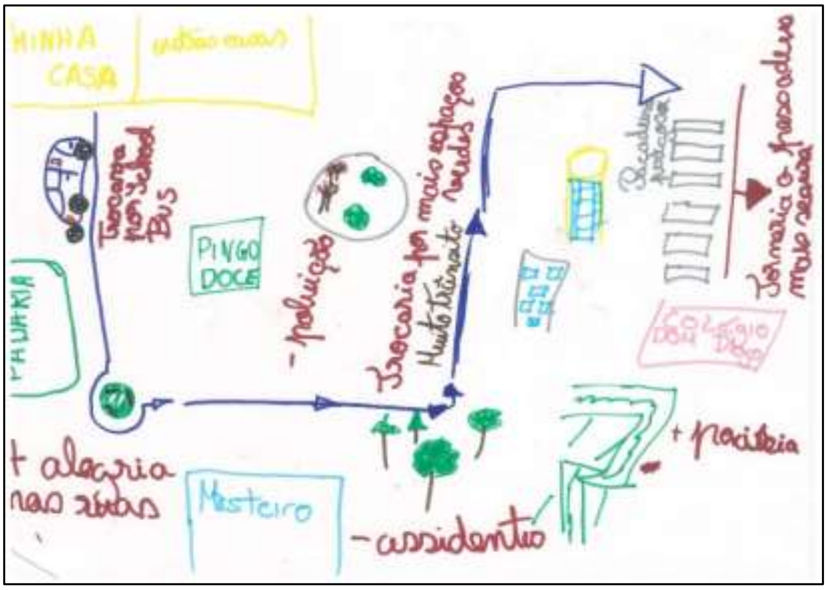


Figure 35: Mental map drawn by a child, who goes by car but would like to go by School Bus, would like less accidents, less pollution, more happiness in the streets, more greenery and safer crosswalks (in dark red), during the Ideas Workshop (Source: Anonymous Student from Ideas Workshop, 2019)

Later, on the participatory mapping phase, the students pointed on the first map (Figure 36 and Figure 37) how they use or would like to use the public space near the school to play, walk, be with friends, and wait for their educational responsible.

Figure 36: Map 01 - What the city means to me. "Which spaces outside the school do you use?" (Source: Adapted by BUILD Technical Team from ITDP Brasil, 2018)

Figure 37: Students filling the map of which spaces outside the school they use or would like to use (Source: BUILD Technical Team, 2019)

On map 2 (Figure 38) showing the BUILD area, they pointed were they felt safe or not, and why. Map 3 (Figure 39) focusing in the surrounding area of the school, the students should also mark where they feel safe or not, and why. In the fourth map (Figure 40), they could indicate where they would consider few interventions. A few examples of the changes they could propose are to paint the street, to paint a crosswalk, to build a parklet, or to add bike lanes, always presented in the tactical urbanism approach. With the fifth map that indicated the intervention area, only presented for the arts students, they could create the street and the cross walking paintings (Figure 41). The three interventions area of Figure 41 were defined after the first Ideas Workshop (Figure 42), considering the propositions of the students complementary to a spatial analysis developed by BUILD technical team. Other examples of filled maps are in Appendix D.

Figure 38: Map 02 - What the city means to me. "Where do you feel more or less safe?" – BUILD Area (Source: Adapted by BUILD Technical Team from ITDP Brasil, 2018)

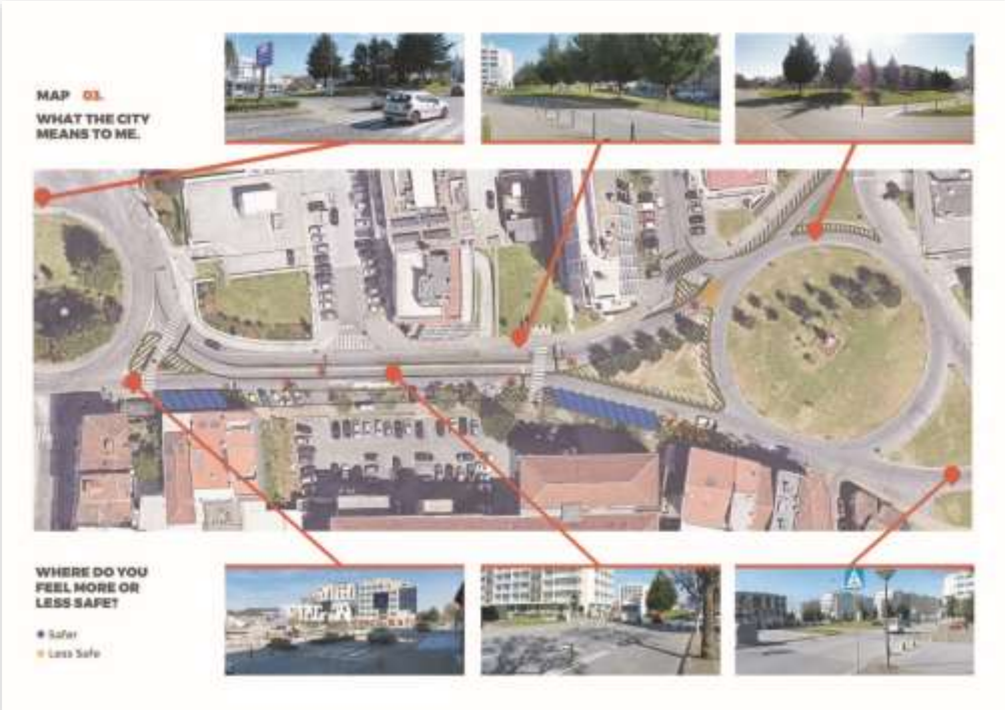


Figure 39: Map 03 - What the city means to me. "Where do you feel more or less safe?" – School Area (Source: Adapted by BUILD Technical Team from ITDP Brasil, 2018)

Figure 40: Map 04 - But this street is also mine... "If you could, where would you propose the following interventions?" (Source: Adapted by BUILD Technical Team from ITDP Brasil, 2018)

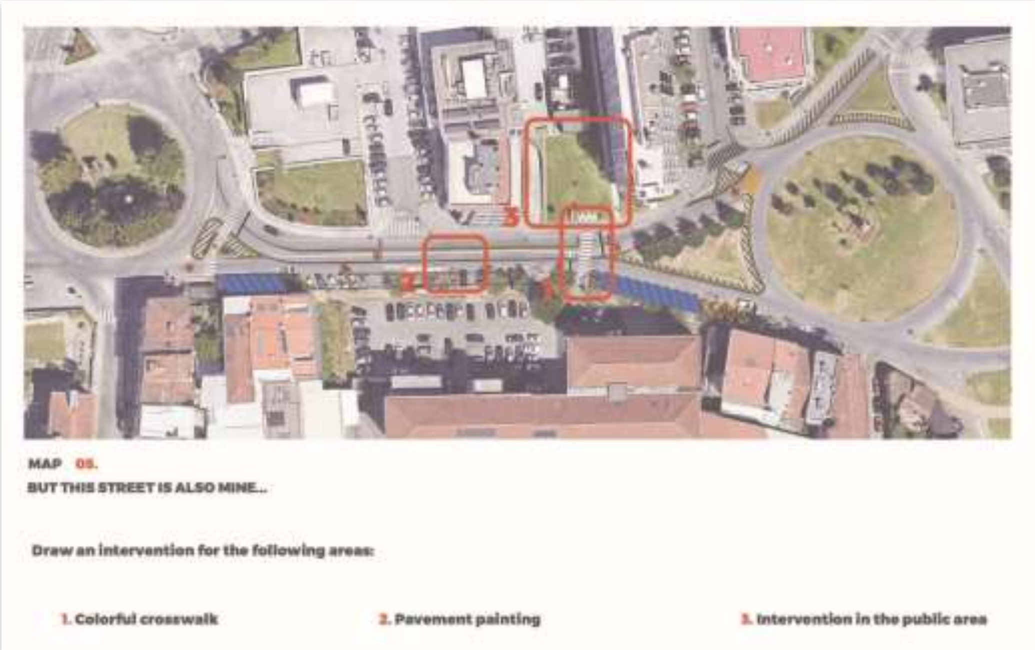


Figure 41: Map 05 - But this street is also mine... "Draw the proposals for the following areas" (Source: BUILD Technical Team, 2019)

Figure 42: Students from Dom Diogo de Sousa School during Ideas Workshop (Source: BUILD Technical Team, 2019)

4.2.4 Focus Groups

The questionnaire covers aspects related to their opinion about the mobility in the city of Braga (Figure 43), which transportation mode they use on daily journeys (Figure 44 and Figure 45), and how they commuted to school back in their childhood. It also covers the impacts of the project School Bus on their daily routine, where they usually park their car to pick up the children (Figure 46), and which was the distance they were willing to walk was there a parking area available (Figure 47), among others. The invitation to join the Focus Group was sent to those who demonstrated interest while filling up the survey about Scholar Transportation and School Bus measure.

Figure 43: Board of perception of the Mobility in Braga filled by educational responsible with words as chaotic, lack of civism, dangerous, and complicated (Source: BUILD Technical Team, 2019)

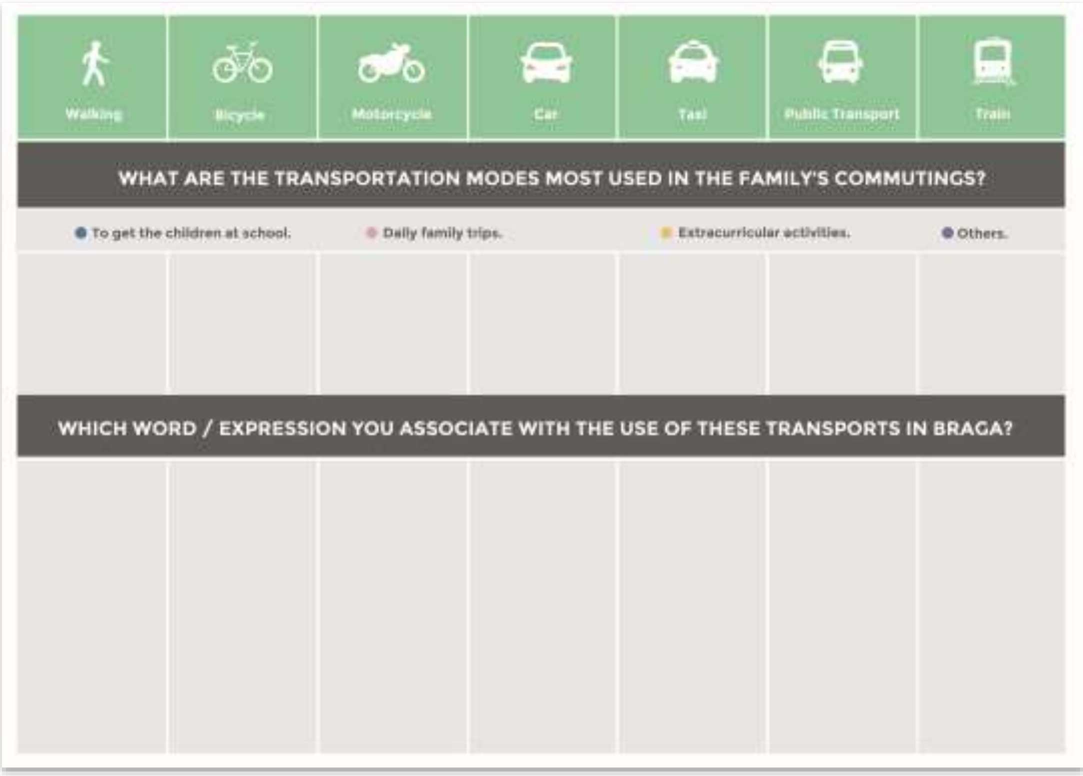


Figure 44: Board of Transportations Modes and Expressions Associated (Source: Adapted by BUILD Technical Team from ITDP Brasil, 2018)

Figure 45: Educational responsible filling the transportation board (Source: Author, 2019)

Figure 46: Board of usually parking spot (Source: BUILD Technical Team, 2019)

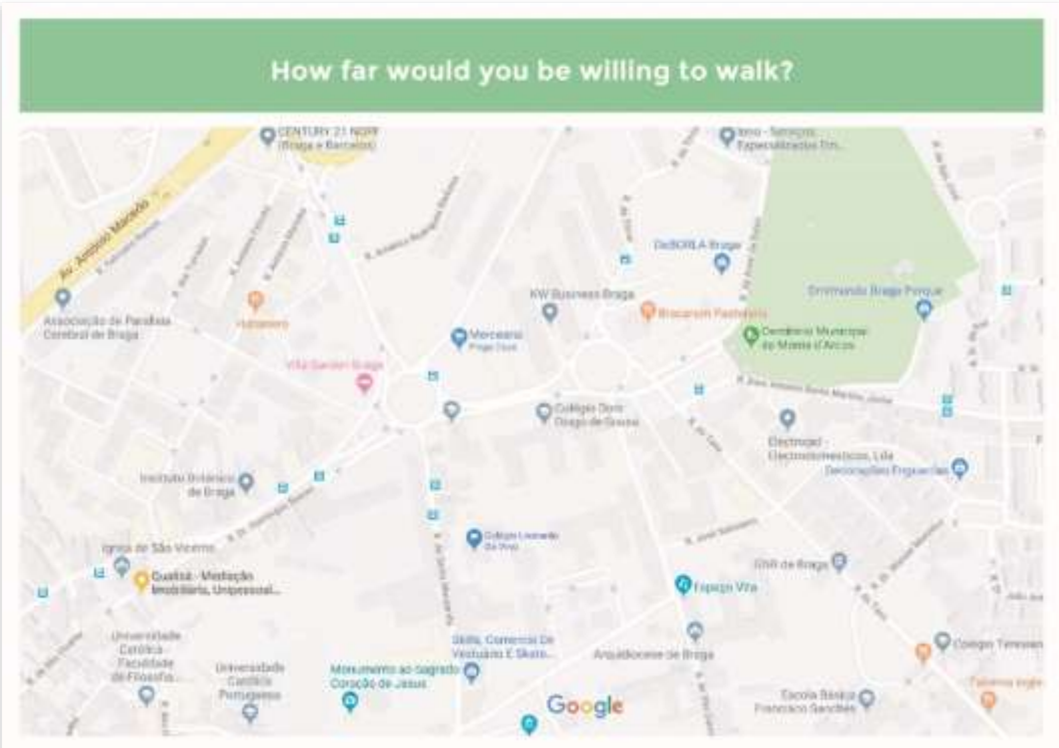


Figure 47: Board of accepted distance to walk (Source: BUILD Technical Team, 2019)

4.2.5 Public Session

Around 700 flyers and 15 posters were distributed to invite the stakeholders for the Public Session that took place in the Largo Monte d'Arcos, near the municipal cemetery (Figure 48).

Figure 48: Poster of Public Session (Source: Adapted by BUILD Technical Team from ITDP Brasil, 2018)

In the first moment, representatives of both CMB and Sao Vicente Parish Council introduced the activity, presenting the BUILD project, its goals and aims (Figure 49). Then, to begin the engagement under the mobility thematic, the stakeholders were invited to play The Big Mobility game (Figure 30), followed by filling a board with one word or expression they associate with "Mobility in the city of Braga" (Figure 43), and a second board with which transportation mode they use on daily journeys (Figure 44).

Figure 49: Public Session on March 30th 2019 (Source: BUILD Technical Team, 2019)

Afterwards, on the participatory mapping phase they completed three different maps presented. On the first map (Figure 50), showing the BUILD area, they pointed how they use the public space near their houses or trade's facility, either to play, walk, be with friends, and access services. In the second map (Figure 38), that also showed the BUILD area, the stakeholders pointed where they felt safe or not, and why. In the third map (Figure 40), they filled where they would consider a few interventions (Figure 51). Other examples of filled maps are in Appendix D. It the end, they were invited to leave a contact detail in case they were interested in participating in the intervention activity.

Figure 50: Map 01 – What the city means to me. "Which spaces do you use?" (Source: Adapted by BUILD Technical Team from ITDP Brasil, 2018)

Figure 51: Stakeholders filling the maps in the Public Session (Source: BUILD Technical Team, 2019)

4.3 Gathered data analysis

Around 327 stakeholders were involved in the actions presented in this study. Children represent 90% of the public engaged, and they are from two schools in the intervention area, Dom Diogo de Sousa School and Leonardo Da Vinci School (Table 9).

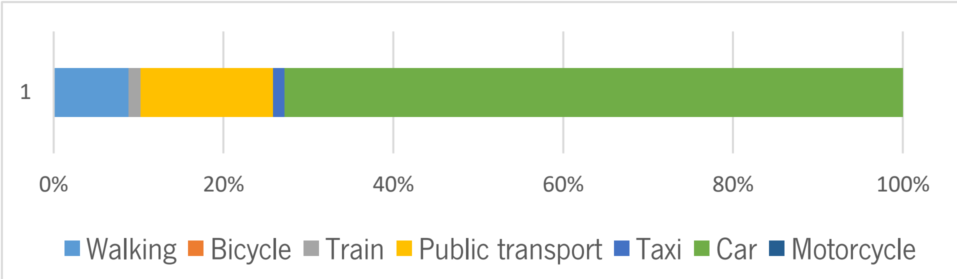
Table 9: Number of stakeholders engaged in each activity (Source: Author, 2019)

Activities		**Public engaged**
Focus Groups	Leonardo Da Vinci School	1
	Dom Diogo de Sousa School	2
Schools' Principals Interview	Leonardo Da Vinci School	1
	Dom Diogo de Sousa School	1
Entities' Interview	Police	1
	President of Sao Vicente Parish Council	1
	Monitor from School Bus	1
	Public Transport Service from Braga	1
	Braga Municipal Council	1
Ideas Workshops	Dom Diogo de Sousa School - Art students	11
	Dom Diogo de Sousa School - 4th class	109
	Leonardo Da Vinci School	22
Mobility as a Game	Leonardo Da Vinci School	140
Public Session	Residents and tradespeople	20
Intervention	General stakeholders	15
TOTAL		**327**

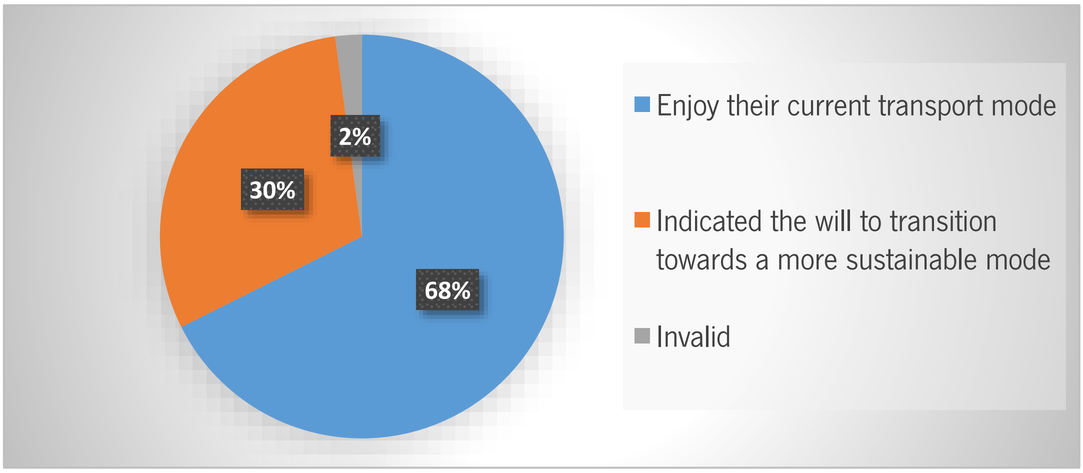
The activities' transcription were analyzed regarding five main categories: traffic; parking; urban infrastructure; urban management; education and behavior. Within urban infrastructure category, there are 21 sub-categories represented by the sustainable mobility measures from Table 3. Then, it was possible to analyze the perceptions and suggestions of the stakeholders under each category. These results are presented along the current section.

The students indicated that the majority of them travel to school by private cars as shown in Graphic 1. Even though, 30% of the total demonstrate the willingness to transition towards a more sustainable transportation mode (Graphic 2 and Graphic 3).

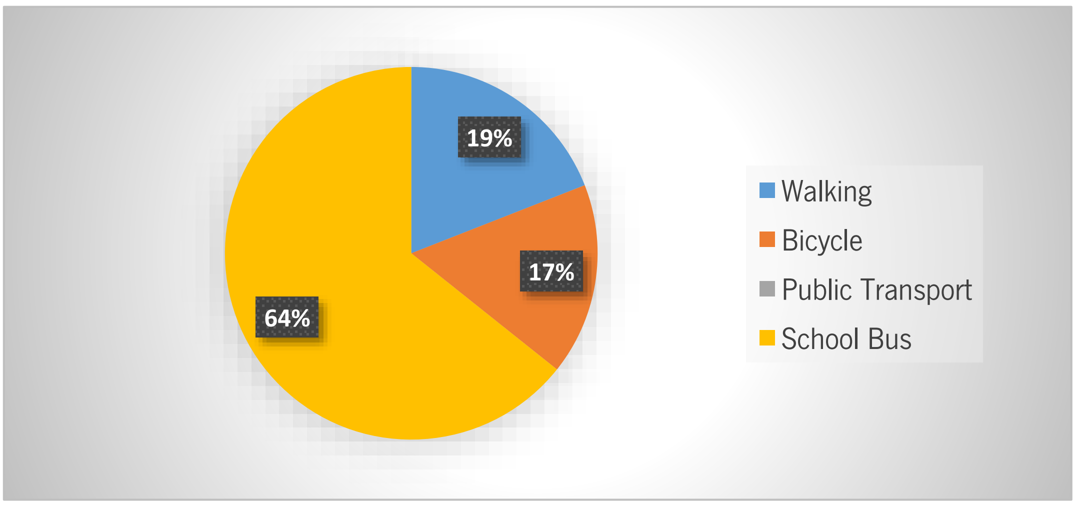
Graphic 1: Modal distribution of students on the commuting to the educational institution (Source: Author, 2019)



Graphic 2: Perception of transport mode option from Mental Maps (Source: Author, 2019)

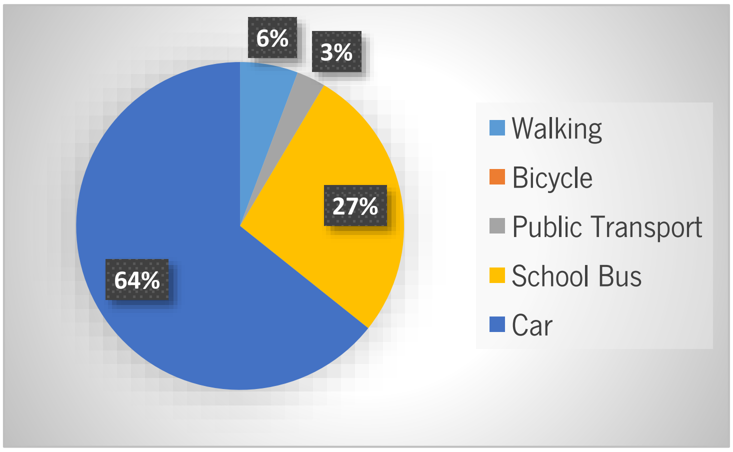


Graphic 3: Modes indicated by 30% of the children willing to transition towards more sustainable transportation modes from Mental Maps (Source: Author, 2019)



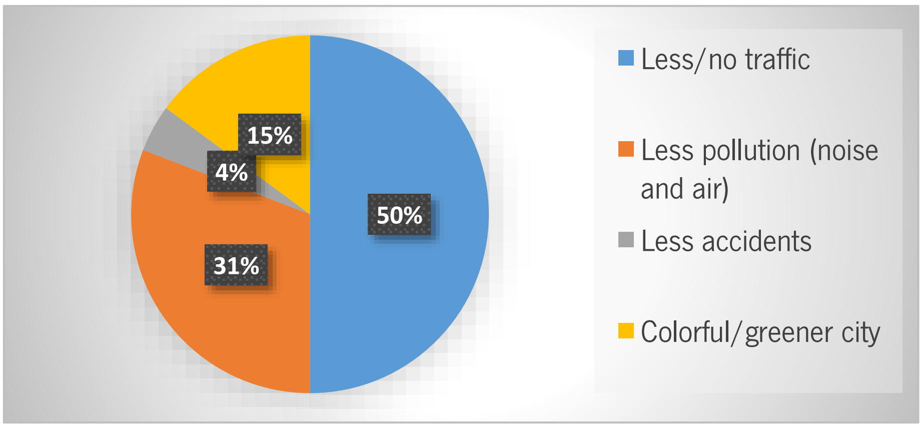
On the other hand, 68% of the students indicate they enjoy the transportation they are currently using on the commuting to school (Graphic 2), whom 64% travels by car (Graphic 4).

Graphic 4: Current transportation mode enjoyed by 68% of the students from Mental Maps (Source: Author, 2019)



The percentage of children who mentioned the desire of having less/none traffic; less air/noise pollution; less traffic accidents; a city more colorful/greener was quantified. From the total, 50% of the students wish the city to have less or no traffic. They also mentioned they would like less pollution, less accidents and a more colorful and with more green areas city (Graphic 5).

Graphic 5: How the children would like the city to be different from Mental Maps (Source: Author, 2019)

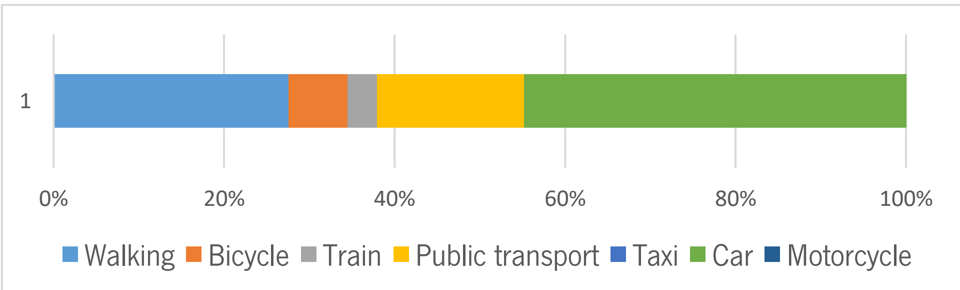


It is also interesting to observe that "traffic" is the main word that stakeholders related to mobility in the city of Braga. The Figure 52 illustrates in a cloud the most mentioned words that the general stakeholders use to describe Braga's mobility. The educational responsible related the traffic with the lack of safety on the streets. In turn, the President of Sao Vicente Parish Council affirmed that once that are benches on the sidewalks and more space for people to be, the people are not going to be afraid of going out to the streets.

Figure 52: Words' cloud of stakeholders' perception of mobility in Braga (Source: Author, 2019)

Regarding the main transportation mode used on daily commuting, the residents indicated the private car (Graphic 6). The residents mentioned the autonomy and flexibility when using private car, while the public transport is described with few available times and routes, although they also mentioned that it is affordable.

Graphic 6: Modal distribution of residents on daily commuting travels (Source: Author, 2019)



In the Focus Groups, the educational responsible also mentioned that public transportation is not efficient in general. This mentioned non-efficience of public transportation eventually explains why the children did not previously mention the public transportation as a mode they would consider when transition towards a more sustainable mode (Graphic 3). The educational responsible mentioned that once it takes around 5 to 10 minutes by car to go to the school, then how will they encourage students to use the public transport if the same journeys takes 1 hour.

The following figures compiled the data gathered from the Ideas Workshops, Focus Groups and Public Sessions. The Figure 53 shows that people feel safe mainly near the schools and in the public park (Figure 21) from BUILD area. The students mentioned the crossing walks in the area are unsafe because the cars move very fast, the crossing walk is not well signposted and are dimly lit. They said the crosswalks that follow the sidewalk should be better signposted as well. In addition there are people who do not cross the street by the crosswalk.

Figure 53: More or less safe feeling (Source: Author, 2019)

As mentioned earlier in Graphic 5, the lack of green areas near the schools is mentioned by the students, and they identified in Figure 54: How they use or would like to use the public space. The red circle indicates the potential area for Tactical Urbanism Intervention (Source: Author, 2019), once it indicates an area they would like to either play, be with friends, or walk. Therefore, they only use the coffee places nearby, the supermarket and the cemetery square (Largo Monte d'Arcos) to be with friends. As a public space, the Largo Monte d'Arcos have only a few benches, which are fixed and distanced from each other (Figure 49 and Figure 51). To play, they indicated the public park, and the roundabouts.

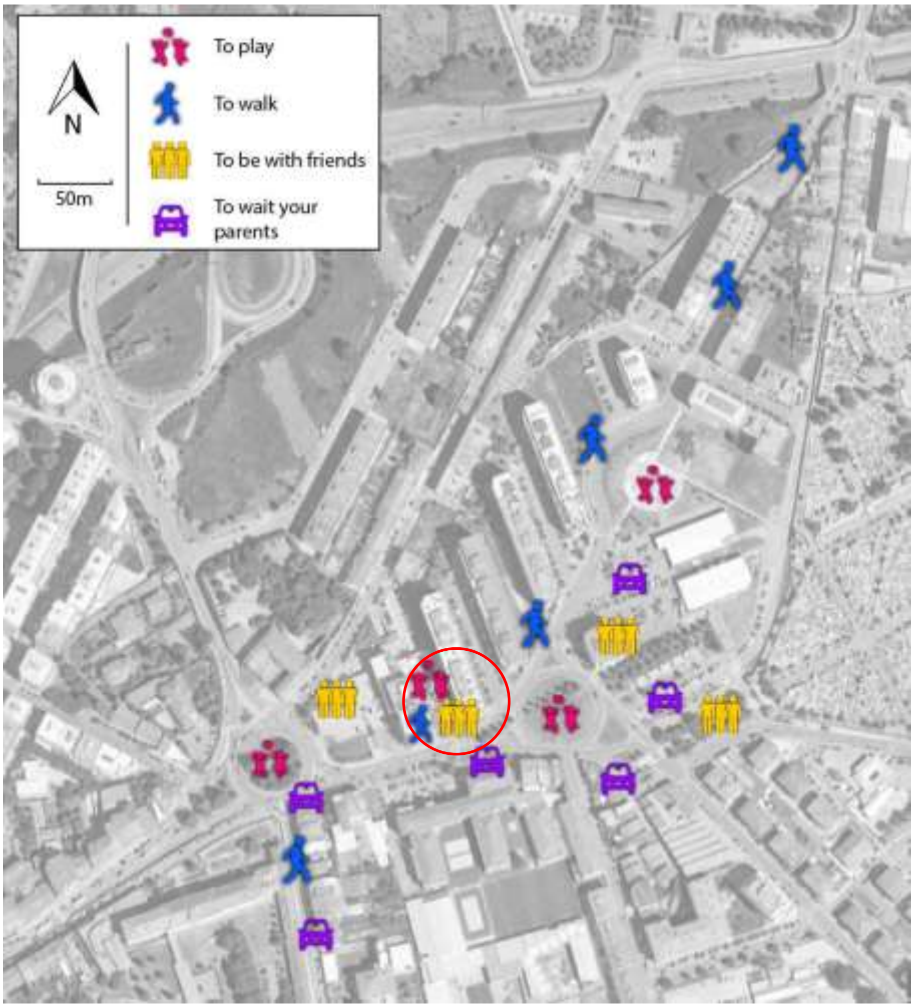


Figure 54: How they use or would like to use the public space. The red circle indicates the potential area for Tactical Urbanism Intervention (Source: Author, 2019)

The area highlighted with the red circle in the Figure 54 currently shares the space with a coffee esplanade. Even though the students mentioned they used to go to the esplanade, they complain about having to consume from the coffee place to have access to the esplanade (Figure 55).

Figure 55: Coffee esplanade and intervention area (Source: Author, 2019)

This mentioned issue of commodification shows the urgent need for public spaces free of market relations. At the same time, as an empty green area, the foot markings on the grass are only in the front section of the area, showing that it is truly an unused greenery public area (Figure 56).

Figure 56: Intervention area and foot markings on grass (Source: Author, 2019)

Then, to understand the active mobility pattern in the area, Figure 57 was also developed indicating the crossings that people irregularly do, that is outside the crosswalks, and that were previously mentioned by the students in IW and observed by BUILD technical team. It is important to highlight that people also indicate the roundabouts as unsafe (Figure 53), although they keep crossing it irregularly. Then, as a result of Figure 54, the pedestrian pathway was represented in Figure 57. The students and the residents mentioned that the sidewalks in general in this area are too narrow, discontinuous and with several architectonical barriers, for instance in the transitions from the sidewalks to the crosswalks, that are often abrupt. Therefore, the identified pathway will be further analyzed and to a future architectonical project's development concerning the improvement of its accessibility.

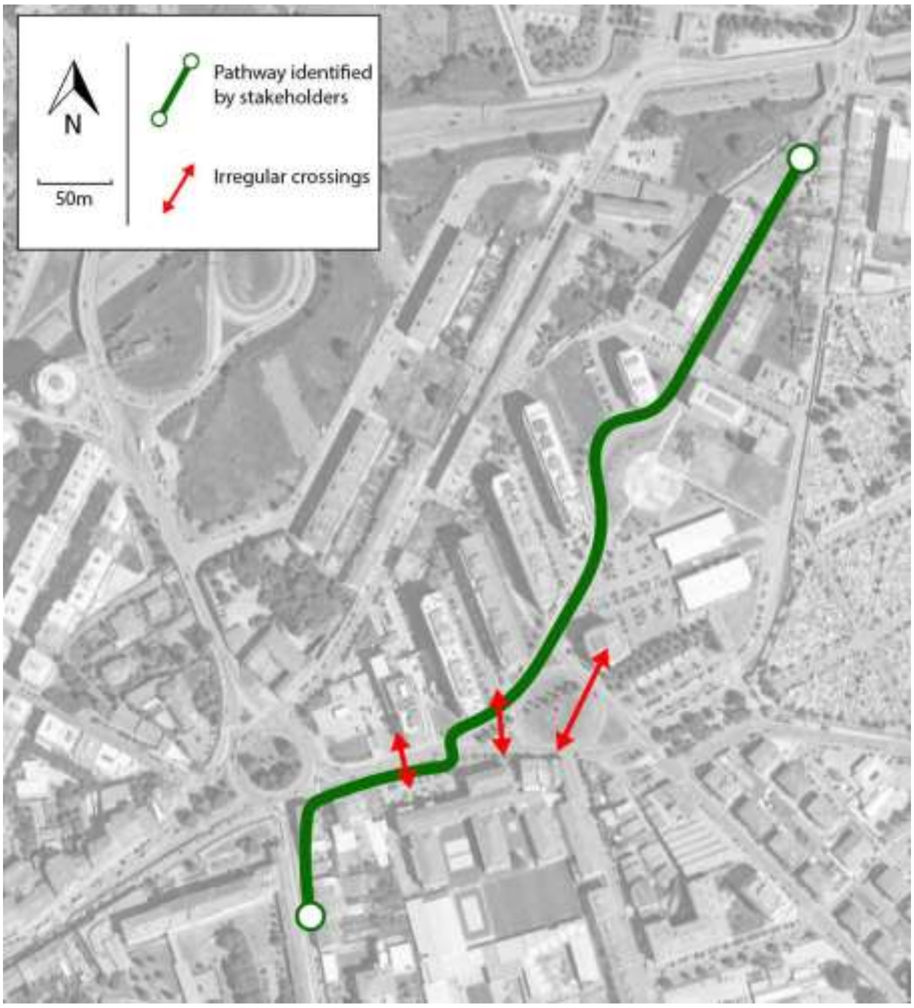
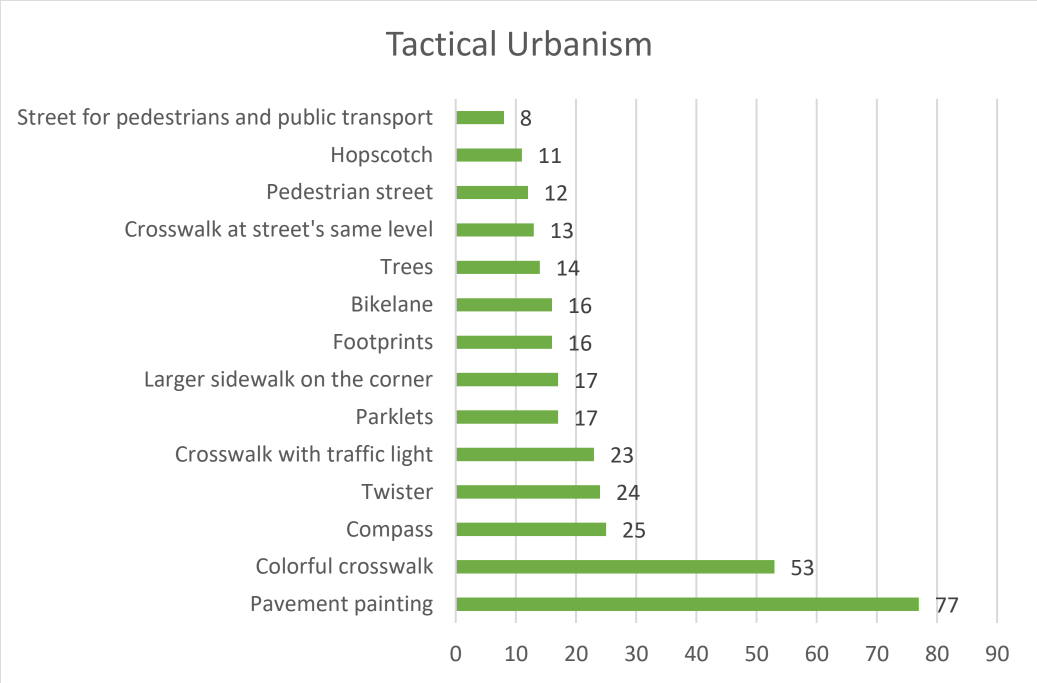


Figure 57: Identified pedestrian pathway and irregular crossings (Source: Author, 2019)

Finally, in the mapping activity of Tactical Urbanism, the most mentioned interventions the stakeholders would like to see in the intervention area are first the pavement painting, and second the colorful crosswalk (Graphic 7).

Graphic 7: Results of Tactical Urbanism (Source: Author, 2019)



4.4 Tactical Urbanism Intervention

Considering the inputs from the analysis of the actions developed along with stakeholders, the structure of the final project was developed, which aimed to work on three different aspects, namely:

i. Activating an underused public space, through building furniture with reused material (SMM 5);

ii. Walking infrastructure improvements for children, through updating the sidewalks with decorative markings and decorative games that invite the children to be active whilst having fun. A crosswalk will be colorful painted, as well as a traffic calming measure as the pavement painting (SMM 5);

iii. Walking and cycling infrastructure improvements, through transforming the sidewalks of the identified pedestrian pathway (Figure 57) into more accessible routes in the connection with every pedestrian crossings (SMMs 5 and 14).

CMB implemented the first aspect right away. The second and third aspects will be later considered in the architectural final project for further implementation. Therefore, the activity named “(Re)using our space” mobilized the stakeholders during one Saturday. It was the last activity from the European Green

Week (Figure 58) developed in Braga and aimed to bring more life for an underused public area in the BUILD area identified by stakeholders, presented in Figure 59. CMB provided the inks and tools, while private partner companies donated the other materials, such as pallets, tires, old school chairs, and electric wire coils. Through reusing those materials, new, fun and colorful urban furniture was developed along with the stakeholders, such as benches and tables (Figure 60).

Figure 58: Poster of European Green Week activities in Braga (Source: BUILD Technical Team, 2019)

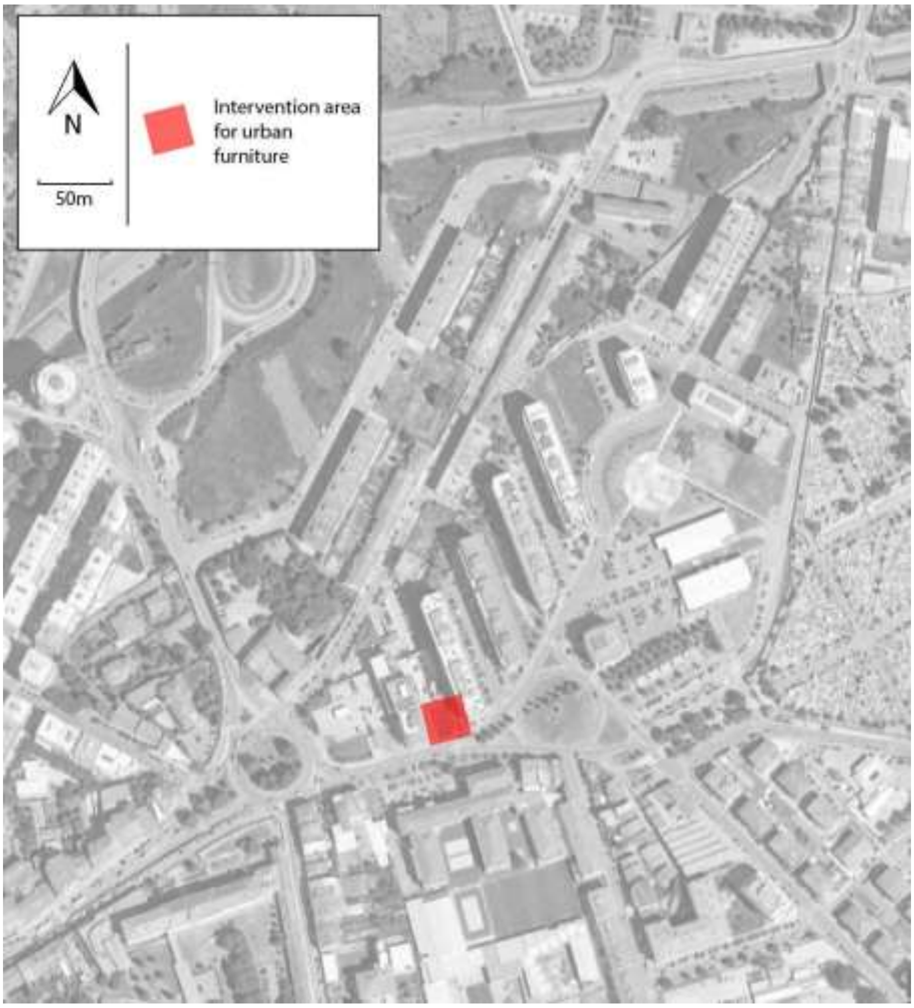


Figure 59: Intervention area defined by Ideas Workshop (Source: Author, 2019)

Figure 60: Activity of Urban Furniture building (Source: Author, 2019)

Through this activity, by placing the furniture in the back section of the area, it was possible to create a space with more life, where the students, residents, and any citizen can enjoy (Figure 61 and Figure 62).

Figure 61: Tactical Urbanism Intervention with Urban furniture (Source: BUILD Technical Team, 2019)

Figure 62: Tactical Urbanism Intervention with Urban furniture (Source: BUILD Technical Team, 2019)

During the following week of the intervention, it was already possible to check some interaction with the furniture (Figure 63 and Figure 64). Furthermore, the creation of live public spaces stimulates citizens to enjoy and appropriate the spaces near their residences and schools, in a way that can contribute to the active mobility. Therefore, it also has a potential to stimulate the transition towards sustainable mobility.

Figure 63: Mother, children and dog in the intervention area (Source: Author, 2019)

Figure 64: Students playing cards in the intervention area (Source: BUILD Technical Team, 2019)

In a second phase, as future works, it is expected to implement the Tactical Urbanism interventions voted by stakeholders (Graphic 7). The Art Students from Dom Diogo de Sousa School, as a result of their Ideas Workshop, developed the drawings for this second phase of intervention, showed in Figure 65 and Figure 66.

Figure 65: Intervention on crosswalk developed by the Art Students from Dom Diogo de Sousa School (Source: Art Students from Dom Diogo de Sousa School, 2019)

Figure 66: Intervention on street as calming measure developed by the Art Students from Dom Diogo de Sousa School (Source: Art Students from Dom Diogo de Sousa School, 2019)

The third phase of intervention, also considered as future works, will consist in developing an architectural project to improve the pedestrian way highlighted in Figure 57. By implementing another SMM 5, it will convert the pedestrian way into an accessible route by removing the architectural barriers of the pathway (Figure 67).

Figure 67: Architectural barriers throughout the pedestrian pathway identified by stakeholders (Source: Anonymous resident sent by E-mail to CMB, 2019)

4.5 PER Framework

To scale-down the PER Framework to BUILD dimensions, first it was necessary to define the potential values of CO_2 emissions reduction for each measure's contribution in Portugal, therefore it was calculated through minimums and maximums values of A-S-I dimensions (Appendix A). In the case of Portugal, it represents 1.27% of the total emissions of CO_2 in Europe. Then to reduce the values from Portugal and adapt it to Braga dimension, it was analyzed that Pisoni et al. (2019) first refined the spatial dimension of analysis through sub-NUTS-3 levels within each NUTS-3 zone. Then, they identified the Functional Urban Area (FUA) for each NUTS-3 zone, and their specific transport activity was estimated, allowing greater precision in the allocation of activity and emissions. Applying the Random Forest model for each FUA covered in the analysis, it resulted in a 642 (FUAs) x 21 (measures) x 3 (coefficients: A-S-I) matrix representing the net impact on emissions reduction across all modes in relative terms (as a share of estimated total urban transport emissions of each FUA).

Although Pisoni et al. (2019) analyzed it for NO_x, they affirm that the same evaluation method, of reduction's percentages, can be replicated, for example, for $PM_{2.5}$ once the considered measures reduce the total traffic, and so it affects other compounds in a similar way. Therefore, the method here considered can also be replicated for CO_2 emissions reduction analysis.

According to European Commission (n.d.) and The Union, Official Journal, & European Union (2018), Braga is located in "NUTS-3 PT112 – Cávado" and its FUA code is "PT003L1". The A-S-I values presented by Pisoni et al.(2019) are specific for each FUA zone, and as the reduction factor for FUA area is the sum of A-S-I values, it allowed the calculation through assessing the contribution of Braga city to the total amount from PT112 – Cávado. The calculation considered the reduction from A-S-I total values of PT112 – Cávado to Braga dimension, through population relation of both Cávado region and Braga city. And so, Braga represents, as the main city of the Cávado region, 72.8% of the A-S-I total values from Cávado region. Then, with the A-S-I total values from Braga each measure contribution was calculated, proportionally to A-S-I total values from Portugal. First by calculating the minimums and maximus of A-S-I, where Braga represents 4.72% of Portugal's Avoid capability, 4.95% of Portugal's Shift capability, and 5.83% of Portugal's Improve capability. Therefore, by adding the A-S-I minimums values and A-S-I maximum values of Braga, the range of minimum and maximus from Braga potential reduction of CO_2 emissions was reached.

Afterwards, for this study it was necessary to adjust the potential reduction values from Braga to BUILD area dimensions. The smaller dimension that is possible to find and compare data inside Portuguese cities is the parish. Therefore, once BUILD major area is located in Sao Vicente parish (Figure 20), the calculation considers Sao Vicente parish data.

Then, to adapt the PER Framework data from Portugal to BUILD area, some variables were analyzed. Namely, to reduce the values from Braga to Sao Vicente parish (considered as BUILD scale), Pisoni et al. (2019) indicate 6 variables that impact the most, according to the Random Forest model, the 21 sustainable mobility measures. Ranking it by importance, the six variables are: 1) Current level of emissions per capita; 2) Passenger car use intensity of NUTS-3 zone; 3) Road accessibility; 4) Rail accessibility; 5) Population density; 6) Total population.

Besides "rail accessibility", Pisoni et al., (2019) indicate that all the other variables contribute positively to the total potential emissions reduction. Suggesting the SUMPs, that apply the sustainable mobility measures, are a higher efficacy in more polluted, dense, car dependent and larger cities, than in smaller cities with a good public transportation system.

Once it implies an analysis between different cities and in the present study a specific area of a city is analyzed, some simplifications were considered. For instance, presented data from "level of emissions per capita" are by cities, and so this variable was not incorporated. "Public transport accessibility analysis" replaced "road accessibility" and "rail accessibility", because it was not possible to find data from road and rail accessibility for such dimension of the city, as parish. "Population density" of the city in comparison with the parish, depends on other parishes' profile, and can result in inaccurate values. Therefore, it was also not incorporated. Thus, the data of "passenger car use intensity", "public transport accessibility" and "total population" were compared.

For "passenger car use intensity", data from MPT (2018) were considered, observing that in Braga 67.3% of total of commuting patterns use private cars. Once it is the major modal used, the value considered was the inner city commuting rates by parish, comparing to the total commuting rate of the city. Another data from MPT (2018) used to analyze "public transport accessibility" was the coverage of the municipal collective road transport service to the resident population of Braga, considering a ten-minute pedestrian movement. Analyzing also the population covered in both Sao Vicente parish in comparison with population covered in total of Braga city. At last, the population relation of all city and those who live in Sao Vicente parish were analyzed (Instituto Nacional de Estatística, 2012).

Afterwards, an impact assessment of Sao Vicente parish in Braga city was carried out by weighing the variables' values according to their importance position in the rank. Finally, the measures weighed arithmetic average in percentage to reach the weighed reduction factor of 7.39% from Braga to Sao Vicente parish (BUILD scale) were calculated (Table 10).

Table 10: Calculation of reduction factor from Braga to BUILD scale (Source: Author, 2019)

Indicator	Unit	Weight	Braga	BUILD scale	Factor	Adjusted Factor
Passenger car use intensity	Number of Vehicles	3	97,808	7,179	7.34%	22.02%
Public transport accessibility	Inhabitants	2	174,517	13,102	7.51%	15.02%
Total population	Inhabitants	1	181,494	13,236	7.29%	7.29%
					Reduction Factor	7.39%

Despite the existing difference between the geographical area of Sao Vicente parish and BUILD influence area (Figure 20), there is a hilly area in the north of Sao Vicente parish that lacks road infrastructure and, due to that, there is no feasible implementation of sustainable mobility measures to reduce CO_2 emissions. Thus, the calculation comes close to the reality and to validate the results, from the global value of CO_2 emission from BUILD influence area (12,594 tCO_2eq) the total potential reduction value of CO_2 emissions calculated for Sao Vicente parish (705 tCO_2eq - 879 tCO_2eq) was deducted, reaching a potential reduction percentage interval of 5.6% - 7.0%. Once the maximum value (7.0%) is in the interval of percentage reduction relative to Portugal calculated by Lopez-Ruiz et al. (2013) of 6.6% - 8.3%, it was theoretically assumed that the PER Framework developed could be used to analyze data from BUILD influence area.

Finally, through this top-down approach, it was possible to create an Analytical Framework of Potential CO_2 Emission Reduction (PER Framework) that allows calculating the potential impact of CO_2 emissions reduction of a project within the BUILD area (Table 11). To actually assess if the measures were being applied a set of possible interventions related to each measure , was defined (Appendix E) that also relate to the Tactical Urbanism possibilities. After defining the existing scenario (section 4.1) and comparing it to a project proposition, the projected final situation calculates only the measures that were new on the area, and results in the potential total amount of CO_2 that is no longer going to be emitted in the area. According to Lopez-Ruiz et al. (2013) it is possible to aggregate the results, only for presentation reasons, because the model does not take into account measure’s overlaps. This calculation assessment is presented in the next section.

Table 11: PER Framework on BUILD influence area scale (Source: Adapted from Lopez-Ruiz et al., 2013)

Analytical Framework of Potential CO_2 Emissions Reduction		**BUILD ($tonCO_2eq/year$)**	
SUSTAINABLE MOBILITY MEASURES		Mín.	Max.
Public transport services			
1	Investment and maintenance, including safety, security and accessibility	34	43
2	Public transport coverage (line density, stop density, walking distances between stops) & public transport frequencies	44	55
3	Interoperable ticketing and payment systems	23	28
4	Taxi services (individual and collective)	28	35
5	Dedicated walking and cycling infrastructure investment and maintenance & Bike sharing schemes	38	47
City logistics and distribution			
6	Improvement of the efficiency of city logistics by the use of ICT	46	57
7	Measures to improve the energy efficiency and environmental performance of vehicles and/or use of alternative modes	30	37

Table 11: PER Framework on BUILD influence area scale (cont.) (Source: Adapted from Lopez-Ruiz et al., 2013)

Analytical Framework of Potential CO_2 Emissions Reduction		**BUILD ($tonCO_2eq/year$)**	
SUSTAINABLE MOBILITY MEASURES		Mín.	Max.
Mobility management			
8	Corporate, school and personalised mobility plans (or workplace travel plans)	33	41
9	Car sharing & carpooling schemes	21	27
10	Telecommunications	49	61
Integration of transport modes			
11	Multimodal connection platforms	15	18
12	Multimodal travel information provision	41	51
13	Park and Ride areas	25	31
Road transport			
14	Reallocation of road space to other modes of transport, e.g. dedicated bus lanes	48	59
15	Parking management	38	47
16	Dynamic traffic management measures	20	25
17	Low speed zones	23	29
Marketing campaigns and education			
18	Information and marketing campaigns	30	38
19	Promotion of eco-driving	7	9
Access restriction schemes			
20	Congestion charging zones (area and cordon charging)	72	90
21	Low emission zones	41	51

4.6 Assessment and Validation of Measures' Impact

The SMMs validated in this study will be "Corporate, school and personalised mobility plans (or workplace travel plans)" and "Information and marketing campaigns", numbers 8 and 18 respectively. In order to determine the reduction of CO_2 emissions from School Bus project's implementation (SMM 8), CTAC's researchers considered the daily number of students using the School Bus. For each month, the average number of students circulating in the School Bus was determined from each interface established to the respective schools (CTAC, 2019). The CTAC's researchers defined a central areas for the School Bus routes, and for the BUILD Schools, its central area is the middle center of the bus route that passes by the Dom Diogo de Sousa School, the Leonardo Da Vinci School and the Teresiano School. For the non-BUILD Schools, the central area is the middle center of the bus route that passes by the School Francisco Sanches EB2,3, School Calouste Gulbenkian and School EB2,3 André Soares. By knowing the route traveled by each bus from the different interfaces and the two defined centroids, the CTAC's researchers established the distances traveled between them. Thus considering that each student that uses the School Bus service is equivalent to a particular vehicle that is no longer circulating in the BUILD area, it was possible to determine the reduction of the traffic existing in the area after the implementation of the SchoolBUS project. Thus it is also possible to calculate the CO_2 emissions reductions through Equation 1, first on daily basis, then monthly, finally the average value of the months, from September 2018 until April 2019, was multiplied by 171 days of school year, reaching the average annual emissions reductions (CTAC, 2019).

In turn, to validate the effectiveness of this participatory planning approach, representing SMM 18, on achieving a change of the current paradigm of mobility and contributing to city's decarbonization, two different stakeholders were considered, both residents and students. For residents, from the Residents' profile survey developed by CECS' researchers, the "yes" answers for the question number 27 (Appendix B) were quantified. For students, the analysis was the quantity of those who considered the possibility of transitioning towards a more sustainable transportation mode on their commuting to school, pointed in their mental map.

Then, similar to the validation calculation for SMM 8, the number of users of School Bus or in this case, the number of people who affirmed the willing of transitioning towards a more sustainable transportation mode, was considered as vehicles. This number was then divided considering the percentage of vehicles by type of fuel (Table 5). For the residents, two journeys were considered, one way to work during the morning, and one way back home, during the afternoon, traveling the distance of 1.8km from a central point in BUILD area until Sao Vicente parish's border. The defined route considered the origin towards the streets with higher amount of traffic and the central point of Sao Vicente parish, until the parish's border (Figure 68). The calculated daily emissions through Equation 1 were multiplied by 226 days of yearly working days, resulting in the total annual emissions for the residents.

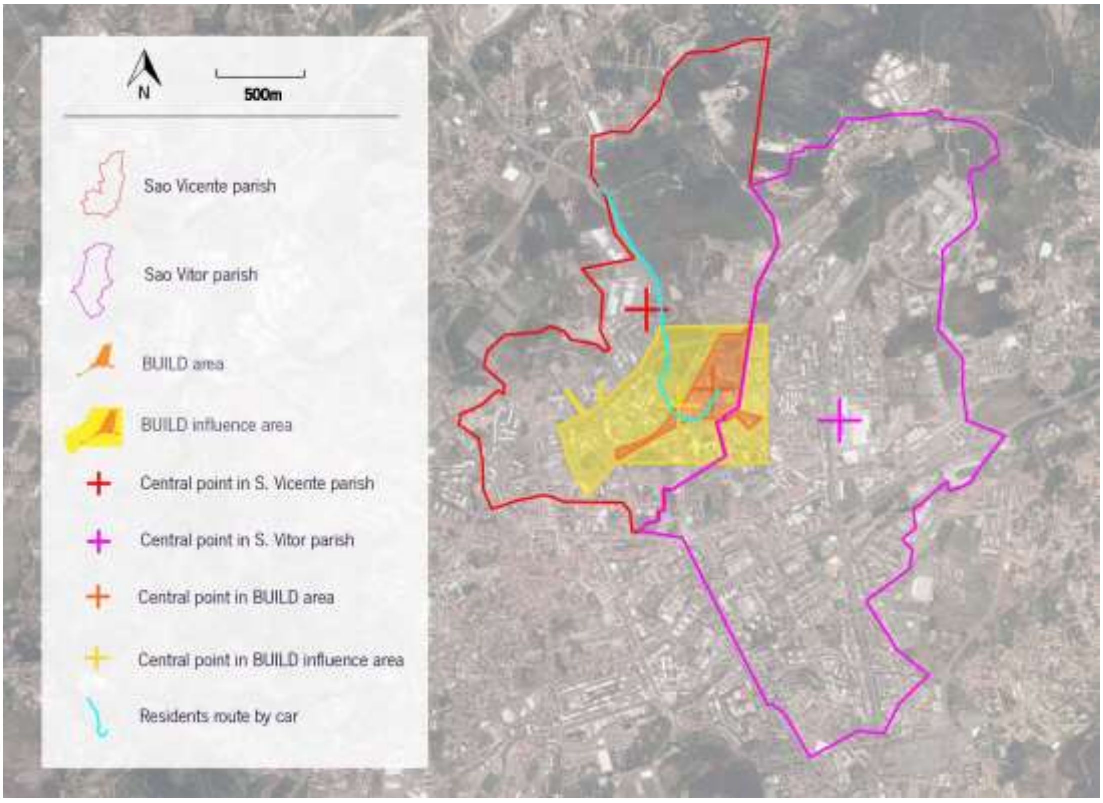


Figure 68: Route by car considered for residents (Source: Author, 2019)

For the students, once the parish where the major number of students live is Sao Vitor (Figure 69 presents the case of Dom Diogo de Sousa School), four trips were considered, two in the morning, to drive the children to the schools, and two in the afternoon, to pick up the children. The distance of 2.1km considered a journey from a central point in Sao Vitor parish towards Sao Vicente parish, passing by the streets with higher amount of traffic, arriving near the schools Dom Diogo de Sousa and Leonardo Da Vinci (Figure 70). The calculated daily emissions through Equation 1 were multiplied by 171 days of school year, resulting in the total annual emissions for the students. Adding its value to the residents annual emissions results in the potential CO_2 emissions reduction of the actions along with stakeholders.

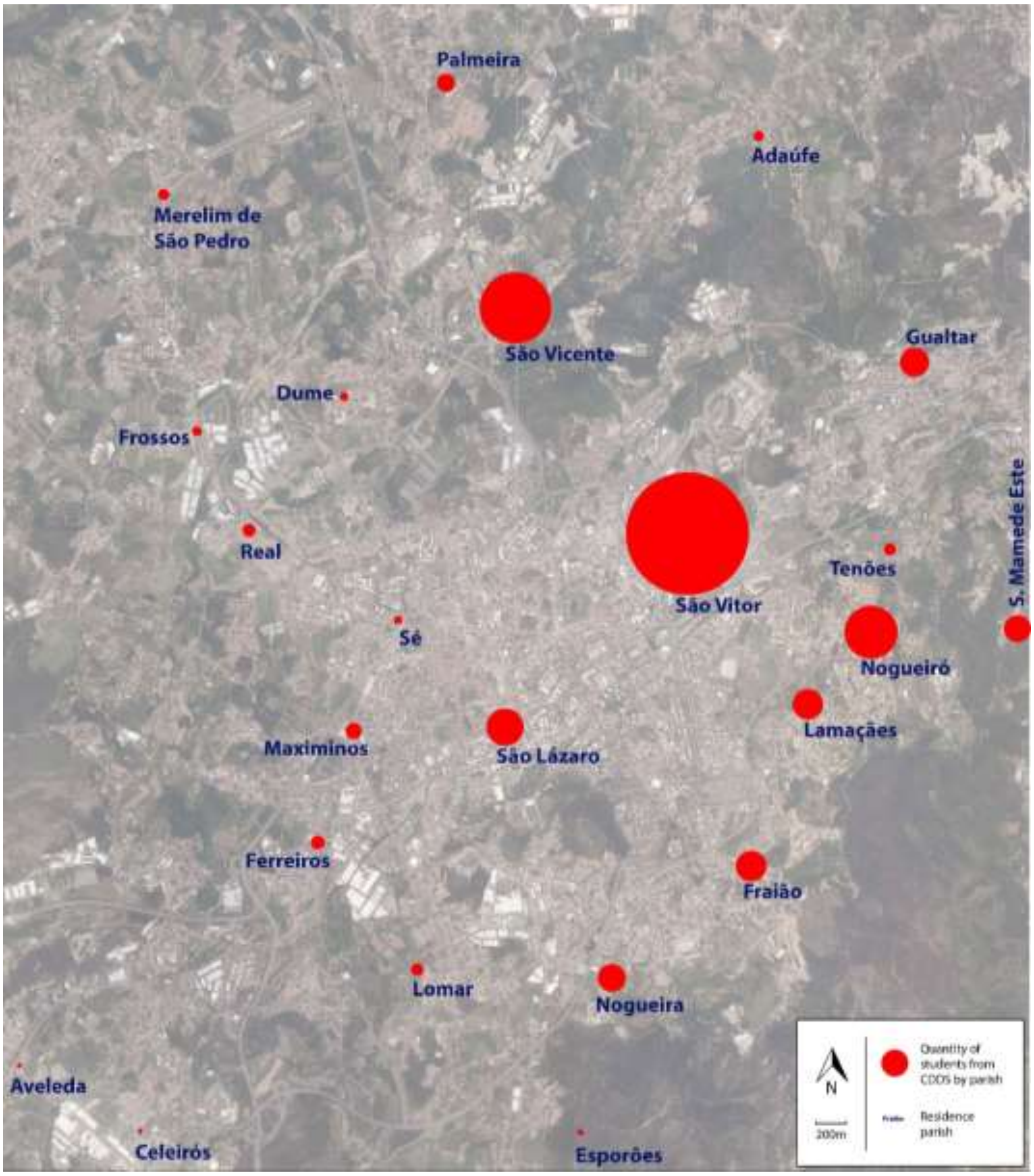


Figure 69: Quantity of students by parish from Dom Diogo de Sousa School (Source: Author, 2019; Database in Appendix F)

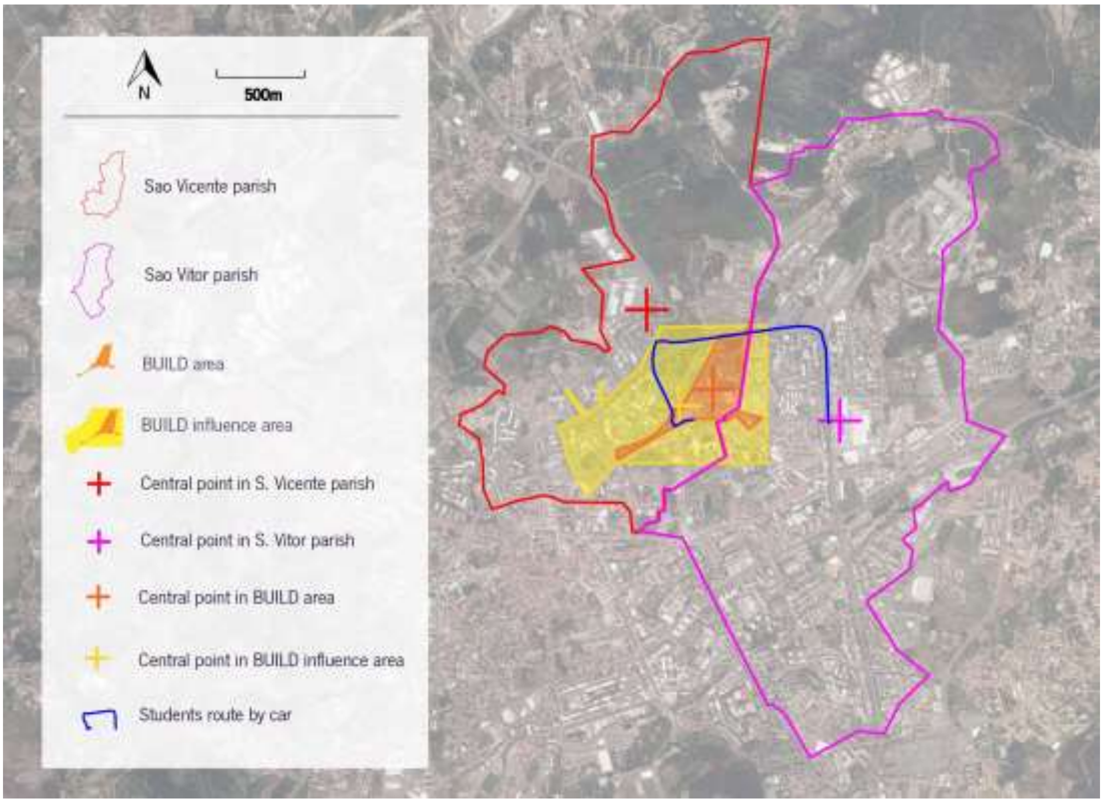


Figure 70: Route by car considered for students (Source: Author, 2019)

The target reduction of the School Bus project (SMM 8) was 0.7% in relation to the reference scenario of BUILD Influence Area, it represents 86.82 tonCO_2eq/year (Câmara Municipal de Braga, 2017). By April, the reduction was 40.2% in relation to the objective, calculated by 34.9 tonCO_2eq/year (CTAC, 2018). Therefore, the value is in the range for SMM 8 in the BUILD influence area, that according to the PER Framework, is between 33 tonCO_2eq/year and 41 tonCO_2eq/year.

The SMM 18, represented in this study as the activities developed along with the stakeholders, was validated through the analysis of the information gathered from 201 answers. From which, 142 are from the student's mental map and the indication of how different they would like it to be in their commuting to school. From those 142 drawings, 43 students demonstrated the willingness to transition towards a more sustainable transportation mode. By considering each student as a private car, it represents a CO_2 emissions reduction of 11.04 tonCO_2eq/year.

Regarding the residents, the CECS' researches received 59 answered surveys, and 33 residents affirmed they would be willing to switch to less polluting modes of transport in order to contribute with the environment in the city of Braga (CECS, 2019). By considering each resident as a private car, it represents a CO_2 emissions reduction of 4.79 tonCO_2eq/year. Therefore, the total amount of the activities' impact is

15.83 tonCO_2eq/year emissions reduction. From PER Framework the range for SMM 18 is between 30 tonCO_2eq/year and 38 tonCO_2eq/year. Which means it achieved around 53% of the minimum value, and to reach the range it would be necessary to have had between 67% and 84% of positive answers of willingness to transition towards a more sustainable transport mode. The calculations resulted in the values presented in Table 12.

Table 12: Values from PER Framework compared with calculated values of BUILD interventions (Source: Author, 2019)

SMM Number	**BUILD Interventions**	**Interventions Calculated Values (tonCO_2eq/year)**	**BUILD Potential CO_2 Emissions Reduction (tonCO_2eq/year)**	
			Min.	Max.
8	School Bus	**34.9**	33	41
18	Actions along with stakeholders	**15.8**	30	38

As mentioned before, the base scenario presented in section 4.1, considered the vehicles counting from 2017, and reached a global CO_2 emission of 12,594.15 tCO_2eq in the BUILD influence area. By adding the potential CO_2 emissions reductions of the interventions in BUILD influence area, it reaches a range of theoretical reduction of 149 tonCO_2eq/year and 185 tonCO_2eq/year (Table 13). It represents a potential reduction between 1.2% - 1.5% of the annual CO_2 emissions of the area.

Table 13: Potential CO_2 Emissions Reduction of BUILD global interventions (Source: Author, 2019)

Considered Sustainable Mobility Measures		BUILD Interventions	BUILD Potential CO_2 Emissions Reduction ($tonCO_2eq/year$)	
			Min	Max
5	Dedicated walking and cycling infrastructure investment and maintenance & Bike sharing schemes	Smart crosswalk; Tactical Urbanism Intervention	38	47
8	Corporate, school and personalized mobility plans (or workplace travel plans)	School Bus projects	33	41
14	Reallocation of road space to other modes of transport, e.g. dedicated bus lanes	Bus lane; Tactical Urbanism Intervention	48	59
18	Information and marketing campaigns	Actions along with stakeholders	30	38
TOTAL*			**149**	**185**

*The sum does not take into account measure's overlap effect, therefore it is only for presentation reasons

5 Conclusions and Future Works

Throughout time, the initial concept of the street as a place where social contact between city-users can be established as a meeting place was devalued. This process of devaluing the concept of the street conducted to the city-users' alienation facing the public space. Which means the scales within the city become so large that relations with the built space become impersonal.

Therefore, in order to promote a transition towards cleaner and more sustainable transport modes a shift from expert technicians into interdisciplinary teams, capable to listen, interact and understand both people and their built environment is deeply needed. Because the planning process is only effective when the community understand it as truly useful and able to improve their quality of life.

Furthermore, this interdisciplinary technical team should strength the stakeholders' network, which involves a high degree of collaboration and communication. To do so, Tactical Urbanism represented an effective catalyst method to introduce this approach of co-created planning processes. Because it creates a link of trust between the technical team and the community stakeholders since it is a concrete, tangible and achievable solution in the short term. Moreover, the citizen's empowerment process in the present case study was only possible due to new governmental policies that afford public collaboration, such as the Living Lab project.

Over the project development four work phases were identified: engagement; motivational; participation; implementation. Once the developed activities figured a prototyped initiative, several difficulties emerged related to the engagement phase. For instance, the involvement of stakeholders was a process that demanded great synergy between the technical team and the representative institutions, such as schools and residents' association, backed up by local government representatives.

The approach to the students was facilitated, once the context of the activities was the educational environment. Therefore, through a hierarchical approach of communication, from the schools' principal, passing by the teachers, and finally reaching the students, the objectives of the activities were partially presented and so, clearer to the students in relation to the residents during the Public Session. Furthermore, the younger stakeholders showed a higher level of interest and participation, compared to the adults.

The gamification through the Mobility Games caught the stakeholders' attention and worked as a great tool in the motivational phase. The stakeholders felt challenged to make no mistakes when answering the questions about sustainable mobility and local traffic laws. For the students, it worked further as a ludic and functional approach to spread the concept of sustainable mobility.

During the participation phase, the technical team needed to adapt the material while the activities were being developed. Regarding the participatory mapping, the maps legibility represented an obstacle to assess the stakeholders' perception of the surrounding environment. In that sense, the photos from specific points from the map helped the stakeholders to better understand the area under discussion as well as the use of satellite images, instead of street maps.

Regarding the implementation phase, the low rate of the population's involvement highlighted the importance of a cohesive and continuous action of engagement. However, once it was a prototype project with a specific period of development, the results of the intervention showed the possibilities of the Tactical Urbanism to truly achieve short-term actions in a way to promote safer and more alive public spaces.

Moreover, the impacts of the actions to promote a behavioral change on behalf of sustainable mobility showed that this is a work in progress. Although the students have shown a desire of a city with less traffic, only 30% understood the need of co-responsibility, which means that they also have to change their transportation mode for a more sustainable one. The residents in turn had a greater acceptance rate with 56% of positive answers to transition towards a more sustainable transportation mode. However, they highlighted a deep need of improvement in the public transportation system as well as in the walking and cycling infrastructure of the city.

At the same time, as a decision-making tool, the PER Framework represented a feasible method when discussing the first applications of Sustainable Mobility Measures in an urban area. The validated values were either in or under the range of values calculated for BUILD influence area. That means if those actions maintain an ascending line of development, and spread out through the urban fabric, the values of CO_2 emissions reduction could continuously rise. By ranking the Sustainable Mobility Measures, regarding the highest impacts on CO_2 emissions reduction, it was possible to group the SMMs in three ranges such as high impact, medium impact, and low impact (Table 14).

The implemented measures in BUILD influence area, by order of highest impact, were SMM 14, 5, 8 and 18. Although 75% of the implemented measures belonged to medium impact range (Table 14), and once these measures were only partially validated, namely through numbers 8 and 18, it was not possible to analyze the overlap effect on it. Even though, it is important to understand which measures can bring major impacts on reducing the CO_2 emissions when taking decisions of projects implementation.

Furthermore, it is remarkable the impact of the School Bus project in Braga. The fact that it began in September 2018 could have contributed to its success on reaching great numbers in CO_2 emissions reduction. It also indicates that the progressive investments on Sustainable Mobility Measures, through public participation, such as Tactical Urbanism activities, represent a possibility to contribute even more with the decarbonization goals of a city.

Table 14: Sustainable Mobility Measures ranked by impact on BUILD influence area scale (Source: Adapted from Lopez-Ruiz et al., 2013)

MEASURES		RANKING	BUILD Potential CO_2 Emissions Reduction ($tonCO_2eq/year$)	
20	Congestion charging zones (area and cordon charging)	**1º (HIGH IMPACT)**	72	90
10	Telecommunications		49	61
14	Reallocation of road space to other modes of transport, e.g. dedicated bus lanes		48	59
6	Improvement of the efficiency of city logistics by the use of ICT		46	57
2	Public transport coverage (line density, stop density, walking distances between stops) & public transport frequencies		44	55
12	Multimodal travel information provision		41	51
21	Low emission zones		41	51
5	Dedicated walking and cycling infrastructure investment and maintenance & Bike sharing schemes	**2º (MEDIUM IMPACT)**	38	47
15	Parking management		38	47
1	Investment and maintenance, including safety, security and accessibility		34	43
8	**Corporate, school and personalized mobility plans (or workplace travel plans)**		33	41
18	**Information and marketing campaigns**		30	38
7	Measures to improve the energy efficiency and environmental performance of vehicles and/or use of alternative modes		30	37
4	Taxi services (individual and collective)		28	35
13	Park and Ride areas	**3º (LOW IMPACT)**	25	31
17	Low speed zones		23	29
3	Interoperable ticketing and payment systems		23	28
9	Car sharing & carpooling schemes		21	27
16	Dynamic traffic management measures		20	25
11	Multimodal connection platforms		15	18
19	Promotion of eco-driving		7	9

Finally, expected future works are possible through the implemented environmental sensors in the area. The air quality measured with those sensors, through quantifying data of pollutant gases (CO_2, CO, NO_x and PM), temperature, humidity, pressure, speed and wind direction, will enable the impacts validation of the implemented Sustainable Mobility Measures, and hence to revalidate the method developed, namely the PER Framework. Moreover, this is a work in progress towards citizens' appropriation of public space and a piece of another contribution for the sustainable mobility promotion in the city of Braga.

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Appendix

Appendix A: 1) Potential CO_2 emissions reductions by Measure for European wide level, and 2) For each country the total value of A-S-I dimensions (Source: Lopez-Ruiz et al., 2013)

1)

Measure	Avoid ktons CO_2	Shift ktons CO_2	Improve ktons CO_2	Potential Reductions 2030 ktons CO_2
1	255 – 319	201 – 256	255 – 319	713 – 894
2	401 – 511	306 – 383	204 – 256	917 – 1,150
3	153 – 192	255 – 319	64 – 80	471 – 591
4	204 – 256	170 – 213	204 – 256	578 – 724
5	306 – 383	408 – 511	68 – 85	781 – 979
6	408 – 511	-	544 – 681	951 – 1,192
7	153 – 192	204 – 256	255 – 319	612 – 767
8	408 – 511	204 – 256	68 – 85	680 – 852
9	255 – 319	(-17) – (-21)	204 – 256	442 – 554
10	306 – 383	510 – 639	204 – 256	1,019 – 1,278
11	102 – 128	204 – 256	-	306 – 383
12	331 – 415	119 – 149	399 – 500	849 – 1,068
13	204 – 256	102 – 128	204 – 256	510 – 639
14	306 – 383	408 – 511	272 – 341	781 – 979
15	178 – 224	340 – 426	263 – 330	781 – 979
16	204 – 256	-	204 – 256	408 – 511
17	153 – 192	255 – 319	68 – 85	476 – 596
18	187 – 234	204 – 256	238 – 298	629 – 788
19	204 – 256	(-102) – (-128)	51 – 64	153 – 192
20	815 – 1,022	408 – 511	272 – 341	1,495 – 1,874
21	204 – 256	306 – 383	340 – 426	849 – 1,065
TOTAL	5,742 – 7,197	4,485 – 5,621	4,379 – 5,488	**14,605 – 18,306**

*Note: All negative values refer to an increase in car use because congestion and/or overall cost goes down

2)

Country	Avoid ktons CO_2	Shift ktons CO_2	Improve ktons CO_2	Potential Reductions 2030 ktons CO_2
AT	71 – 88	55 – 69	54 – 67	179 – 225
BE	155 – 194	120 – 151	118 – 147	393 – 493
BG	39 – 49	31 – 38	30 – 38	100 – 125
CY	6 – 7	5 – 6	4 – 6	15 – 19
CZ	104 – 130	81 – 101	79 – 99	263 – 330
DE	1,060 – 1,329	828 – 1,038	809 – 1,014	2,694 – 3,381
DK	59 – 74	46 – 58	45 – 57	151 – 189
EE	15 -18	11 – 14	11 – 14	37 – 47
ES	418 – 524	327 – 410	319 – 400	1,064 – 1,333
FI	64 – 80	50 – 63	49 – 61	163 – 204
FR	847 – 1062	662 – 830	646 – 810	2,156 – 2,702
GR	73 – 92	57 – 72	56 – 70	187 – 234
HR	27 – 34	22 – 27	21 – 26	70 – 88
HU	65 – 82	51 – 64	50 – 62	166 – 208
IE	26 – 33	21 – 26	20 – 25	67 – 84
IT	884 – 1,108	691 – 867	675 – 846	2,250 – 2,821
LT	39 – 49	31 – 38	30 – 37	100 – 125
LU	11 – 13	8 – 10	8 – 10	27 – 34
LV	20 – 26	16 – 20	16 – 20	52 – 65
MT	4 – 4	3 – 3	3 – 3	9 – 11
NL	188 – 236	147 – 184	143 – 180	478 – 599
PL	246 – 308	192 – 241	188 – 235	625 – 784
PT	**73 – 91**	**57 – 71**	**56 – 70**	**186 – 233**
RO	64 – 80	50 – 63	49 – 61	163 – 205
SE	126 – 158	99 – 124	96 – 121	321 – 403
SI	8 – 10	6 – 8	6 – 7	20 – 25
SK	79 – 99	62 – 77	60 – 76	201 – 252
UK	971 – 1,217	756 – 948	738 – 925	1,465 – 3,090
TOTAL	5,742 – 7,197	4,485 – 5,621	4,379 – 5,488	**14,605 – 18,306**

Appendix B: Resident's survey (Source: CECS, 2019)

Inquérito por questionário à população residente da área BUILD

No âmbito de um diagnóstico sobre mobilidade, eficiência energética e descarbonização da sua área de residência, desenvolvido pelo Centro de Estudos Comunicação e Sociedade (CECS) da Universidade do Minho, em articulação com a Câmara Municipal de Braga, solicitamos a sua participação na resposta às perguntas que colocamos no presente questionário, nomeadamente sobre práticas de mobilidade, usos do tempo e consumos energéticos. O questionário é de preenchimento simples e leva apenas alguns minutos. A informação recolhida é tratada de forma anónima. Desde já agradecemos a sua colaboração.

O questionário deverá ser devolvido até ao dia 12 de abril de 2019 nos pontos de entrega referidos na carta em anexo.

I – Área de residência

1. Indique por favor, o(s) motivo(s) para ter escolhido esta área para residir:

Preço-qualidade da habitação	
Proximidade aos estabelecimentos de ensino	
Proximidade aos locais de trabalho onde desenvolve atividade profissional	
Oferta de bens e serviços	
Oferta e acesso a transportes públicos	
Elemento(s) do agregado familiar natural(ais) da área	
Outro. Qual?	

2. Há quantos anos habita nesta área? ____anos.

3. Tem filhos em idade escolar?

Sim		Não	

3.1 Se sim, qual a distância de casa à escola dos seus educandos? (definir uma média, caso tenha filhos em escolas /distâncias diferentes)

<500m		3km a 5km	
500 m a 1km		5km a 10km	
1km a 3km		>10km	
Não se aplica			

4. Das seguintes atividades, indique aquelas que normalmente realiza na área onde reside (no exterior da sua casa).

Fazer refeições	
Encontrar-se com amigos e familiares	
Praticar desporto	
Fazer compras rotineiras de abastecimento da casa (comida e outros artigos)	
Fazer compras não rotineiras (roupa, acessórios, decoração, etc.)	
Aceder a serviços (banco, multibanco, correios)	
Brincar com os (as) meus (minhas) filhos (as)	
Desfrutar de partes do meu dia em lazer	
Outras. Quais?	

5. Pensando na sua área de residência, assinale até que ponto está satisfeito/a com cada um dos aspetos.

	Nada satisfeito/a	Pouco satisfeito/a	Satisfeito/a	Muito satisfeito/a
Proximidade às escolas				
Acesso a serviços (banco, CTT, multibanco)				
Acesso a serviços de proximidade (hipermercados, cafés...)				
Áreas de lazer				
Proximidade ao local de trabalho				
Segurança pedonal e ciclável				
Fluxo de trânsito				
Fluxo de transportes públicos				
Outro. Qual?				

6. Se indicou não estar satisfeito/a com alguns aspetos, assinale o que devia ser feito para melhorar?

____

____

____

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7. Quais são os espaços favoritos na cidade para lazer familiar?

Na sua freguesia: ______________________________

Noutra freguesia: ______________________________

II – Consumos e Práticas

8. A residência onde habita é:

Vivenda	
Apartamento	
Outra. Qual?	

9. Quantas quartos tem a sua residência? ____________________

10. Qual a área aproximada (em metros quadrados)?________________

11. A residência onde habita tem:

Caraterização	Sim	Não	Não sei
Isolamento térmico nas paredes exteriores			
Janelas com vidro duplo			
Certificado energético			
Se sim, qual a classe energética?			

12. A sua casa é confortável?

De inverno	Sim		Não	
De verão	Sim		Não	

12.1. Se sim, assinale o que faz para tentar melhorar as condições de conforto térmico:

Inverno			**Verão**		
Não abre as janelas	**Sobe estores/ abre as cortinas**	**Liga o aquecedor /lareira /sistemas de aquecimento**	**Abre/fecha as janelas**	**Baixa os estores/persianas, fecha as cortinas**	**Liga ar condicionado**
Outra:					

13. Utiliza fontes de energia para aquecer ou arrefecer a casa?

Aquecimento	Sim		Não	
Arrefecimento	Sim		Não	

13.1. Se sim, assinale qual:

Gás	Lareira	Lareira com recuperador de calor	Eletricidade	Energia renovável
Outra:				Qual:

13.2. Qual a percentagem do orçamento familiar gasta em aquecimento e/ou arrefecimento?

< 5%	< 10%	< 15%	> 20%	Só aquecimento
Outra:				

14. Das seguintes características assinale o que mais valoriza na compra de eletrodomésticos e, se for o caso, de automóveis? (assinale até DUAS opções).

O preço	
A marca	
O seu design	
O menor consumo energético	
O desempenho	

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III– Práticas de mobilidade

15. As deslocações que os membros em idade adulta do seu agregado fazem com mais frequência, são normalmente:

Dentro do concelho de Braga. Freguesia (indique o nome) ______________________________	
Para outros concelhos. Qual/Quais?____	

16. Pensando de uma forma global sobre os meios de transporte utilizados pela sua família, assinale a frequência com que são usados:

Meios	Nunca	Ocasionalmente	1 vez por semana	2 a 3 vezes por semana	Todos os dias
Carro					
Mota					
Transportes públicos					
Modo pedonal					
Avião					
Comboio					
Bicicleta					
Outro. Qual?___________________					

17. Em relação ao meio de transporte mais utilizado, qual (quais) o (s) motivos (s) para essa opção em termos familiares? (assinale até três opções)

Por ser mais barato	
Por ser mais cómodo	
Por ser mais rápido	
Porque precisa de o usar para fins profissionais (reuniões, visitas a cliente, etc.)	
Porque precisa de o usar para outros fins (filhos na escola, transporte de outras pessoas, fazer compras ou outras atividades)	
Porque não há transportes públicos em condições de o servir	
Outra situação	

18. Para cada uma das atividades assinaladas a seguir e realizadas pelos membros adultos do agregado indique o tipo de meio de transporte usado com mais frequência.

Atividades	**Carro**	**Mota**	**Transportes públicos**	**Modo pedonal**	**Avião**	**Comboio**	**Bicicleta**	**Não se aplica**
Para ir para o emprego								
Para levar as crianças à escola								
Para levar as crianças a atividades extracurriculares								
Para fazer compras								
Para fins profissionais								
Para férias								
Outro motivo:_________________								

19. Sobre o meio de transporte que mais usa na viagem casa-escola e escola-casa assinale o motivo pelo qual o utiliza.
(pode selecionar mais que uma opção)

Porque segue viagem para o trabalho		Porque é mais cómodo	
Porque é mais seguro para a criança		Porque é mais económico	
Porque a escola é longe de casa		Porque é mais rápido	
Preocupações ambientais		Outro. Qual?	

20. Se usa o automóvel para as deslocações casa-trabalho, partilha com alguém o transporte ou vai sozinho/a?

Vou sozinho		Divido com mais pessoas		Quantas pessoas?______________

Caso não tenha automóvel passe para a questão 28.

21. Quantos automóveis existem no seu agregado familiar e qual o combustível utilizado por cada veículo?

Nº de automóveis	Gasolina	Gasóleo	GPL	Elétrico	Híbrido
1					
2					
3					
4+					

22. No total do agregado familiar, quantos quilómetros são feitos por semana (em média) de automóvel?

Menos de 100km	Entre 100km e 250km	Entre 250km e 500km	Mais de 500km

23. Considerando o local onde vive e todas as tarefas que realiza diariamente, o automóvel é indispensável no seu agregado?

Sim		Não	

24. Para si, o carro é... (Assinale até duas opções)

O meu prazer especial, algo que tem a ver com o que eu sou	
Indispensável, só com ele vou onde quero, quando quero	
Algo de essencial para o conforto e qualidade de vida da minha família	
Um instrumento de trabalho, fundamental para o meu dia-a-dia profissional	
Algo que tenho que ter porque não se consegue viver em Braga sem carro	
Algo que me é útil em certas circunstâncias, mas de que poderia perfeitamente prescindir	
Outro. Qual?	

25. Quais são as principais dificuldades que encontra no dia-a-dia relacionadas com as deslocações que tem de fazer (relacionadas com o agregado familiar)?

____

____

26. Neste momento, se pudesse comprava um carro elétrico?

Sim		Não		Talvez	

27. Para ajudar o ambiente na cidade de Braga estaria disposto(a) a trocar a utilização do automóvel por modos de transporte menos poluentes?

Sim		Não		Talvez	

28. Quando usa o espaço público para andar a pé ou de bicicleta, sente-se seguro/a?

	Sempre	Sim, a maior parte das vezes	Não, raramente	Nunca
A pé				
De bicicleta ou trotineta				

29. Que medidas propõe serem implementadas na envolvente da sua residência para promover e possibilitar a deslocação a pé e de bicicleta de forma segura, particularmente para as crianças, idosos e pessoas com mobilidade reduzida?

____

____

____

30. Nas tarefas abaixo descritas, quanto tempo demora na deslocação:

	Menos de 15min	Mais de 15 até 30 minutos	Mais de 30min a 1h	Mais de 1 a 2h	Não se aplica
De casa até ao trabalho					
De casa até à escola dos seus educandos					
De casa à escola e depois até ao trabalho					
A fazer compras					
A levar os educandos a atividades extracurriculares, a partir da escola					

31. Qual a atividade que considera que despende mais tempo, do seu dia a dia?

____

____

32. Com que frequência se sente apressado(a)?

Nunca		Raramente		Frequentemente		Sempre	

32.1. Caso se sinta apressado/a, qual o principal motivo?

____

____

VI – Avaliações

33. O que o preocupa mais na sua área de residência?

Preocupações	Nada preocupante	Pouco preocupante	Preocupante	Bastante preocupante	Muito preocupante
A poluição atmosférica					
Os acidentes rodoviários					
O trânsito (circulação lenta)					
A falta de transportes públicos					
A qualidade da infraestrutura pedonal (largura útil, continuidade)					
O estacionamento abusivo					
A localização das passadeiras					
O atravessamento da rua em locais indevidos					
A falta de segurança no atravessamento da passadeira					
O número excessivo de veículos					
O conflito na circulação entre automóveis e peões					
O incumprimento das normas de circulação					
A falta de locais de estacionamento					
A circulação insegura					
Outra. Qual?					

34. Assinale a disposição do seu agregado para por em prática cada uma das ações assinaladas a seguir.

Comportamentos	Sempre	Quase sempre	Às vezes	Nem sempre, mas estamos interessados	Nunca e não estamos interessados	Não se aplica
Desligar equipamentos elétricos quando não estão a ser usados						
Desligar as luzes quando a divisão da casa não está ocupada por ninguém						
Usar lâmpadas economizadoras						
Lavar o carro menos vezes						
Usar energia solar para aquecimento de águas						
Usar energia solar para a produção de energia elétrica						
Optar por eletrodomésticos que consomem menos energia elétrica						
Investir no isolamento térmico da habitação						
Fazer descargas curtas nos autoclismos						
Reutilizar águas domésticas						
Fechar as torneiras quando a água não está a ser utilizada						
Passar a usar mais transportes públicos nas deslocações						
Fazer mais deslocações a pé, de bicicleta ou trotineta						
Usar automóvel elétrico ou hibrido						
Partilhar o veículo nas deslocações em automóvel						
Fazer separação do lixo para reciclagem						

35. Quem se preocupa mais no seu agregado com questões ambientais?______________________________

36. Com base nas seguintes afirmações indique-nos a sua opinião sobre a sustentabilidade ambiental.

Frases	Discordo totalmente	Discordo	Não concordo nem discordo	Concordo	Concordo totalmente
As alterações climáticas são um problema que me preocupa.					
Temos o dever de deixar um planeta sustentável para as gerações futuras, mesmo que isso implique sacrificar em parte o conforto do nosso modo de vida atual.					
Só os governos podem contrariar os efeitos das alterações climáticas e implementar medidas em favor da sustentabilidade ambiental					
A minha ação individual vale muito pouco no combate à poluição e às alterações climáticas.					
Não estou muito disposto(a) a adotar comportamentos mais sustentáveis, se não houver vantagens imediatas para mim e para a minha família.					
A mudança de comportamento para uma vida mais sustentável deve começar a nível local.					
A sustentabilidade deve ser uma das prioridades da governação da cidade de Braga.					

VI - Informações pessoais sobre quem preencheu o questionário e agregado a que pertence

37. Género: ______________________

38. Idade:_____________

39. Nível de escolaridade: ______________________________________

40. Atividade profissional: (descreva p.f. o melhor possível) ____

41. Indique para cada elemento do agregado familiar a informação solicitada.

Elementos do agregado	Grau de parentesco (em relação a quem preenche o questionário)	Idade	Nível de escolaridade	Atividade profissional (descreva p.f. o melhor possível)
Elemento 1				
Elemento 2				
Elemento 3				
Elemento 4				
Elemento 5				
Elemento 6				

42. Presentemente qual é o nível mensal do rendimento líquido do seu agregado familiar? (após descontos de impostos e segurança social)

até 600 euros	
de 601 a 1000 euros	
de 1001 a 2000 euros	
de 2001 a 3000 euros	
mais de 3001 euros	

43. Acrescente por favor, qualquer informação que julgue pertinente sobre o assunto que tratamos neste questionário.

____

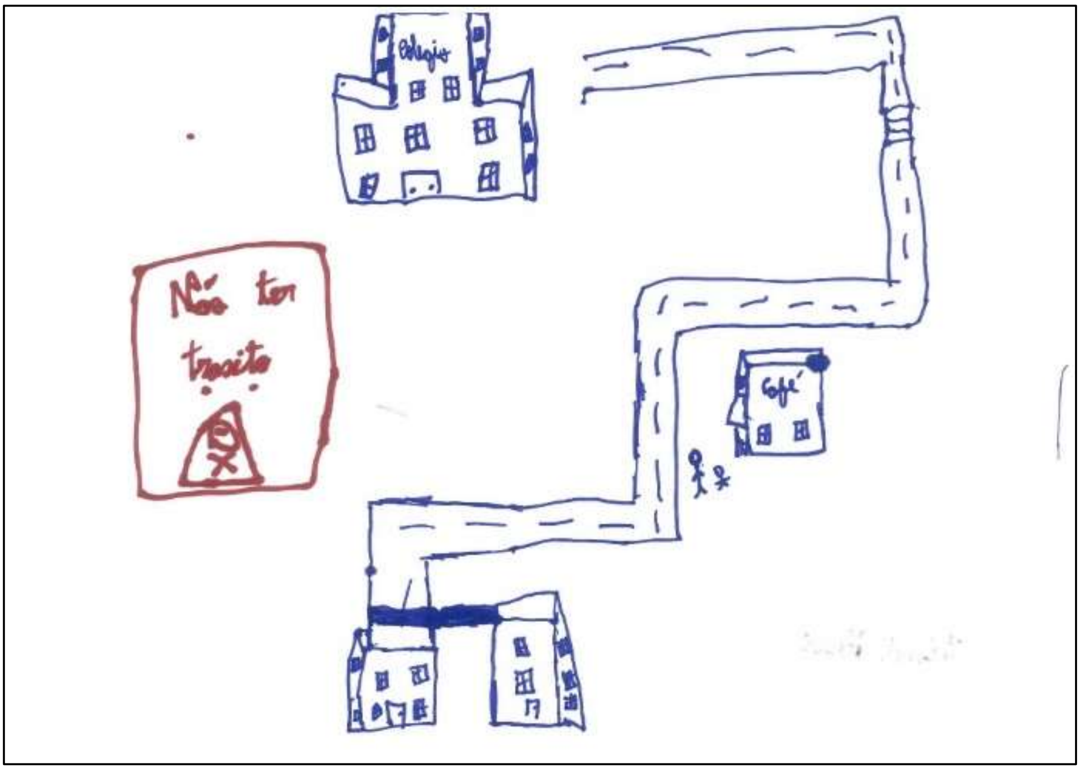
____

O questionário deverá ser devolvido até ao dia 12 de abril de 2019 nos pontos de entrega referidos na carta em anexo.

AGRADECEMOS A SUA COLABORAÇÃO!

Appendix C: Six other mental maps drawings from children (Source: Anonymous Students from Ideas Workshop)

1) The child would like to have less traffic in the city



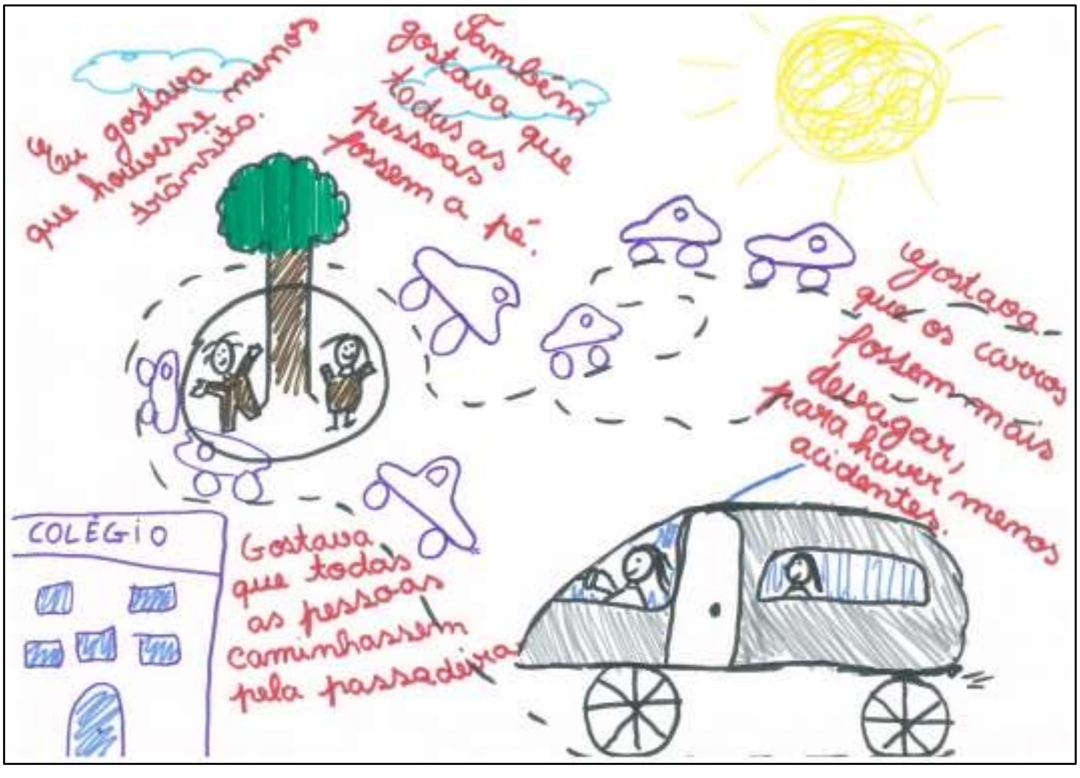
2) The child goes by School Bus and desires less mobiles, more friends and less vehicles

3) The child goes by car and would like to go by School Bus

4) The child goes by car and would like less traffic and to walk to school

5) The child goes by car and said the electric cars are the best solution for less pollution

6) The child goes by car and would like less traffic, and that everyone walked and crossed over crosswalks, and the cars to drive slower to avoid accidents.



Appendix D: Six examples of filled maps and boards from participatory mapping phase of Ideas Workshop and Public Session (Source: Author)

1) Map 01 filled in the Ideas Workshop with Art Students of Dom Diogo de Sousa School

2) Map 02 filled in the Ideas Workshop with Art Students of Dom Diogo de Sousa School

3) Map 03 filled in the Ideas Workshop with Art Students of Dom Diogo de Sousa School

4) Filled board of transportation mode from Public Session

5) Map 01 filled in by stakeholders from Public Session

6) Map 02 filled in by stakeholders from Public Session

Appendix E: Measures x Interventions

	SUSTAINABLE MOBILITY MEASURES	INTERVENTIONS
	Public transport services	
1	Investment and maintenance, including safety, security and accessibility	Improvement of existing stops
2	Public transport coverage (line density, stop density, walking distances between stops) & public transport frequencies	More stops / bus lines
3	Interoperable ticketing and payment systems	Integrated bus and train ticket
		Integrated bus and bicycle ticket
4	Taxi services (individual and collective)	Cabstand
5	Dedicated walking and cycling infrastructure investment and maintenance & Bike sharing schemes	Pedestrian streets
		Cycleway/Bikelane implantation
		Shared bicycle spot
		Longest crossing time
		Smart crosswalk
		Crosswalk at street's same level
		Larger sidewalk on the corner
	City logistics and distribution	
6	Improvement of the efficiency of city logistics by the use of ICT	Implementation of ICT equipment
7	Measures to improve the energy efficiency and environmental performance of vehicles and/or use of alternative modes	Investment on less polluting motor technologies
	Mobility management	
8	Corporate, school and personalised mobility plans (or workplace travel plans)	School Bus Service
9	Car sharing & carpooling schemes	Organization of Car Sharing schemes
10	Telecommunications	Teleconferencing practices in institutions
	Integration of transport modes	
11	Multimodal connection platforms	Multimodal Interfaces
12	Multimodal travel information provision	Implementation of equipment and eletronical signals
13	Park and Ride areas	Park and Ride areas
	Road transport	
14	Reallocation of road space to other modes of transport, e.g. dedicated bus lanes	Buslanes
		Cycleway/Bikelane implantation
15	Parking management	Predict or remove paid parking
16	Dynamic traffic management measures	Implementation of traffic sensors
17	Low speed zones	Complete/shared street
		Calming measures
		Mini-roundabout
		Leisure areas
	Marketing campaigns and education	
18	Information and marketing campaigns	Campaigns on Inclusive and Sustainable Mobility
19	Promotion of eco-driving	Campaigns on efficient use of vehicles for fuel economy
	Access restriction schemes	
20	Congestion charging zones (area and cordon charging)	Rate of access to a particular zone during peak hours
21	Low emission zones	Planning of zones and implementation of environmental sensors

Appendix F: Number of students by parish studying in Dom Diogo de Sousa School in 2018-2019 (Source: Information provided by Dom Diogo de Sousa School, 2019)

Parish	City	Students
São Victor	Braga	287
São Vicente	Braga	167
Fraião	Braga	143
Nogueiró	Braga	124
São José de São Lázaro	Braga	87
Lamaçães	Braga	71
Gualtar	Braga	68
Nogueira	Braga	65
Este (S. Pedro e S. Mamede)	Braga	63
Palmeira	Braga	43
Maximinos	Braga	38
Ferreiros	Braga	32
Real	Braga	30
Lomar	Braga	29
Tenões	Braga	28
Merelim São Pedro	Braga	26
Adaúfe	Braga	24
Frossos	Braga	22
Dume	Braga	20
Sé	Braga	19
Esporões	Braga	14
Aveleda	Braga	11
Celeirós	Braga	11