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The smart city concept and its application: the case of Guimarães.

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Dissertação realizada no âmbito do Mestrado em Riscos, Cidades e Ordenamento do Território, orientada pelo Professor Doutor José Alberto Rio Fernandes

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Honor declaration

I hereby declare that this thesis/dissertation/report is of my authorship and has not been used previously in another course, degree, curricular unit or subject, at this or any other institution. References to other authors (statements, ideas, thoughts) scrupulously respect the rules of attribution and are duly indicated in the text and bibliographical references, in accordance with the rules of referencing. I am aware that the practice of plagiarism and self-plagiarism is an academic offence.

I further declare that have not used generative artificial intelligence tools (chatbots based on large language models) to carry out part(s) of this thesis/dissertation/report, and that all interactions (prompts and responses) have been transcribed in the annex.

Porto, 9th September, 2024

David José Taveira de Barros

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Resumo

O crescimento de população tem levantado sérias questões sobre a sustentabilidade dos recursos. Esta questão tem sido mais debatida no âmbito das cidades devido à sua procura por parte de todos aqueles que procuram melhores condições de vida. Foi neste contexto que se desenvolveu o conceito de Smart City ou cidade inteligente. Compete aos municípios darem resposta às questões que melhorem a qualidade de vida dos seus munícipes. Esta dissertação/relatório foi desenvolvido no âmbito de um estágio realizado no Departamento de Desenvolvimento do Território do município de Guimarães.

O estudo teve como objetivo avaliar como Guimarães está a responder ao desafio de se tornar uma cidade inteligente. Para isso, foram realizadas entrevistas com especialistas em planeamento urbano, trabalhadores do município e um inquérito com os utilizadores do município: residentes, trabalhadores e estudantes, tendo obtido 101 respostas válidas. Procurou-se avaliar a congruência entre aquilo que os decisores consideram importante no planeamento do município e aquilo que os utilizadores (do município) percecionam como importante. Analisaram-se as nove componentes utilizadas pelo município no alinhamento com o conceito de cidade inteligente. Estas abordagens refletem uma perspetiva interna da cidade.

Os resultados mostram que o município está envolvido no desenvolvimento de soluções inteligentes voltadas para a neutralidade carbónica, mobilidade inteligente, gestão de água e resíduos, e melhorias na experiência turística. Ao comparar com outras cidades de perfil sociodemográfico similar, percebe-se o compromisso do município de Guimarães com o desenvolvimento de um território sustentável e inovador, evidenciado pelas atividades internacionais em que a cidade participa.

Em termos de congruência, há um alinhamento geral entre as prioridades do município e as perceções dos utilizadores da cidade. No entanto sobressaíram alguns resultados interessantes e inesperados pois os respondentes parecem valorizar menos a componente “participação dos cidadãos” do que o município. No entanto, algumas sugestões apontam uma falta de valorização desta categoria por parte do município.

Embora existam limitações metodológicas, que podem ser colmatadas em estudos futuros, pesquisas futuras podem ainda complementar a perspetiva interna com a visão externa dos visitantes do município.

Palavras-chave: Congruência, Guimarães, Perspetiva interna, Smart city, Sustentabilidade

Abstract

Population growth has raised serious concerns about the sustainability of resources. This issue has been most widely debated in urban areas, where many people are drawn in search of better living conditions. It is within this context that the concept of the Smart City, or intelligent city, was developed. Local governments are responsible for addressing issues that enhance the quality of life for their residents. This dissertation/report was produced as part of an internship at the Department of Territorial Development in the municipality of Guimarães.

The aim of the study was to assess how Guimarães is responding to the challenge of becoming a smart city. To achieve this, interviews were conducted with urban planning experts and municipal workers, along with a survey of residents, workers, and students in the municipality (101 valid answers). The study sought to evaluate the alignment between the priorities of decision-makers in city planning and the perceptions of the city's users regarding the nine components employed by the municipality to define a smart city. Therefore, providing an internal perspective on the city.

The findings reveal that the municipality is actively developing smart solutions focused on carbon neutrality, mobility, water and waste management, and enhancing the tourism experience. When compared with other cities of a similar sociodemographic profile, it becomes clear that Guimarães is committed to fostering a sustainable and innovative territory, as evidenced by the city's participation in international activities.

In terms of alignment, there is general congruence between the municipality's priorities and citizens' perceptions. However, some unexpected and noteworthy results emerged, with respondents placing less emphasis on citizen participation. One suggestion indicated that this category may be underappreciated by the municipality.

Despite certain methodological limitations, the study suggests that future research could complement this internal perspective with insights from external visitors to the municipality.

Key-words: Alignment, Guimarães, Internal perspective, Smart city, Sustainability

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Introduction

The development of cities, its urban planning and its impacts on people has cached the attention of the author of this research since always. This interest increased while studding smart cities in his bachelor in Geography and Planning in the University of Minho and developing it in this master program in the University of Porto.

Intelligent cities or smart cities have been a topic of significant interest and investment in recent years, with numerous initiatives and projects underway in various parts of the world (Gracias et al., 2023). Taking that into account it was decided to study this concept and its application while developing this dissertation/report.

After discussing it with my thesis supervisor we decided to develop research on smart cities while developing an internship at Guimarães city council. This decision was taken because Guimarães has been trying to develop the city and its surroundings in an intelligent way. This fact has been witnessed by several communication channels and even by the author of this research for he was born, studied and has been living in Guimarães ever since. In line with this, a program has been developed by the author together with his thesis supervisor Professor Doutor José Alberto Rio Fernandes (FLUP) and Architect Pedro Sousa, who is the responsible for the department of the urban planning of Guimarães in the city council and was the supervisor/responsible of this internship.

A research question was formulated: “How is Guimarães responding to the challenge of becoming a smart city?”

The general objective of this dissertation/report is to contribute to knowledge of the city and, if possible, to provide insights to improving Guimarães as a "smart city", considering what the city has done in recent years focusing in the year of 2023.

Accordingly, the specific objectives were outlined:

SO 1) To synthesize the encounter between the theoretical dimension - what a "smart city" is (should be) and what Guimarães has done, is doing and intends to do;
SO 2) To compare Guimarães' path with that of other cities;
SO 3) To evaluate the congruence between what the decision makers are doing regarding the development of Guimarães as a smart city and the perspectives of the people who live, work or study there.

To answer the research question, the general and the specific objectives we used triangulation between methods as defined by Denzin (1970, 1989). Specifically, we used a mixed approach between qualitative analysis (SO 1 and SO 2) and quantitative analysis (SO 3).
The type of research design proposed is also related to the data type and the approach. The conjunction between qualitative and quantitative methods is commonly used to provide a more comprehensive understanding of the research problem.

Qualitative methodology is considered more subjective, as researchers study phenomena in their natural settings based on the meanings people attribute to them; it involves various forms of investigation, where the data used do not easily lend themselves to quantification, specification, objectification, or classification. Consequently, standard statistical procedures are not applicable for data display or analysis. Content analysis (Bardin, 2018) was the technique used to analyse the interviews. This approach focuses on identifying and categorizing patterns and meanings within the data.

On the other hand, quantitative methodology is viewed as more objective, involving the collection and analysis of numerical data to describe, predict, or control variables of interest. To accomplish the specific objective 3 (SO 3) a survey was developed by means of a questionnaire that was designed to be answered by people who use the city: live, work or study in Guimarães. Therefore, a convenience sample was extracted from this population considering the personal and professional relations of the author of this report.

The primary advantage of quantitative methods is their ability to generalize results to larger populations. Yet, quantitative methodology may miss the richness and depth of human experiences, emotions, and behaviours to fully comprehend some aspects of the phenomena. Therefore, the combination of both methods generally offers a more comprehensive understanding of it. Further details can be found in the methodology topic.

The structure of this dissertation/report is as follows. It is divided in **two main parts** and a conclusion. Firstly, a **literature review** is performed exploring the concept of smart city, the historical development of smart cities, models of smart cities, examples of smart cities (IDM smart cities index 2023; relevant smart cities' projects, and smart cities collected from Pilot Studies). Finally, a conclusion of the literature revision is drawn (topics 1 to 4).

The second part consist of the development of the **empirical research** (topics 5 to 8). We begin this part by describing the context of the internship in the city council. Then a comparison between Guimarães and other smart cities is drawn. Methodology is explained and justified and then data analysis is performed and interpreted.

Finally, a **conclusion** is drawn considering the literature revision and the analysis of the empirical research.

PART 1

Literature review

Reviewing literature means to search the existing knowledge about a subject (Oliveira, 2011). The central subject of this dissertation/report is smart cities.

This topic discusses the concept of smart city, then provides knowledge on the most recognized models on this subject and some examples of smart cities. Finally, addresses an overview on the activities that Guimarães is developing and intends to develop to become a smart city by comparing it with Pilot Studies on smaller smart cities among European Union and Europe.

A great part of this literature review was developed with the help of the tool www.connectedpapers.com with the purpose of finding papers connected with the subject. This search hadn´t any geographic nor linguistic boundaries for, according to Eco (2007) one cannot develop a thesis about an author or a theme by reading only literature written in the languages that we know. Yet, it is commonly accepted that all the relevant literature is written in English language therefore most of the search found is in English.

1. The concept of Smart City

There are many concepts to define what a Smart City is, although not always well applied or sometimes defined in a vague, imprecise and/or superficial way.

Smart cities are necessary to overcome current challenges such as population growth and globalization.

The first urban big data project is the one developed in Los Angeles in the 1970s, marking the beginning of the smart city movement. Amsterdam is the first fully committed smart city, having established a virtual digital city in 1994. Nonetheless, the idea gained

popularity in the middle of the 2000s following a significant breakthrough and implementation of communication technology [1]

Since the early 1990s, the idea of living in intelligent or smart cities has gained traction (Batty, 1990; Gibson et al., 1992). From 2010 onward, it has gained specific academic recognition as a "new urban planning paradigm or set of business strategies rather than as an operating urban system" (Komninos, 2016, p. 197).

In general, smart cities provide solutions based on the deployment of new Information and Communication Technologies (hereafter, ICT) (Neirotti et al., 2014). Due the technology has taken a place over the years, “smart city” was though as a “digital city”, at first (Conti and Rosati, 2016). Washburn et al. (2010) said that smart cities use computing technologies to make their critical infrastructure and more intelligent, interconnected, and efficient services. Therefore, smart city is an urban development vision to integrate information and communication technology (ICT) and Internet of things (IoT) technology in a secure fashion to manage a city’s assets[2].

However, being a smart city is not just having the technology as its strength, because when a smart city invests in human and social capital, transport and ICT, the city should attain sustainable economic growth and a high quality of life through a wise management of natural resources and participatory governance (Caragliu et al., 2011). It’s also relevant to mention the mediatism of climate change and how the cities should do for adapting to this. According Gonçalves (2018) a city with a lower rate of environment can’t be called an “intelligent city”. Thus, the technology of smart cities is interconnected with sustainability, comfort, security and attractiveness (Lazaroiu and Roscia, 2012).

Woods (2020) describes that smart cities seek more effectiveness and incarnation of the sustainable city. According to the University of Orgeon a smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future

[1] https://finance.yahoo.com/news/history-smart-cities-timeline-130515562.html accessed on 20 April 2024

[2] https://www.ierek.com/news/smart-city-city-future/ accessed on 20 April 2024

generations with respect to economic, social, and environmental aspects. (ITU-T Focus Group).

A smart city goes beyond the use of digital technologies for better resource use and less emissions. It means smarter urban transport networks, upgraded water supply and waste disposal facilities and more efficient ways to light and heat buildings. It also means a more interactive and responsive city administration, safer public spaces and meeting the needs of an ageing population.

For European Commission (2023)[3], a smart city is more than just a place where digital technologies are used to reduce emissions and optimize resource consumption. It entails improved waste management and water supply systems, more intelligent urban transportation networks, and more effective methods of heating and lighting buildings. It also entails satisfying the requirements of an aging population, safer public areas, and a more involved and responsive local management.

It's possible the emphasize of sustainability in city. More recently the in October 2015, ITU-T Study Group 5 agreed on the following definition of a Smart Sustainable City states that a smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well a cultural aspect[4].

According to the EU (European Union), the concept of a Smart City is associated with a set of systems and people that interact intelligently using energy, materials, services and resources in a sustainable way to benefit citizens and businesses.

A Smart City works in an integrated way with its citizens to improve the various areas of cities (safety, health, cleanliness, transportation, public lighting, and mobility, among others). To do this, it uses technology and innovation to improve the quality of life of its

[3] https://commission.europa.eu/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en accessed on 18 April 2024
[4] https://www.itu.int/en/ITU-T/focusgroups/ssc/Pages/default.aspx accessed on 18 April 2024

inhabitants, increase the economic value generated in that community and promote environmental sustainability.

With the advance of technology, there are now more and more innovations that contribute to the growth of the Smart Cities concept and that can be applied in the daily lives of citizens. (Yet, 2021).

There are many concepts of smart cities. A selection of examples following different authors are provided in the table below.

***Table 1**: The smart City concept according to different authors organized by date*

Authors	Smart city concept
Hall et al. (2000)	A smart city monitors and integrates the conditions of all its critical infrastructure (e.g., roads, bridges, airports), optimizes its resources, plans its preventive maintenance activities, and monitors security aspects while maximizing services to its citizens.
Giffinger & Kramar (2007)	A smart city refers to the search and identification of intelligent solutions that allow modern cities to enhance the quality of the services provided to citizens.
Eger (2009)	A smart community is a community that makes a conscious decision to aggressively deploy technology as a catalyst to solve its social and business needs.
Chen (2010)	Smart cities take advantage of communications and sensor capabilities sewn into the cities' infrastructures to optimize electrical, transportation, and other logistical operations supporting daily life, thereby improving the quality of life for everyone.
Harrison et al. (2010)	A city is smart when it connects the physical, IT, social, and business infrastructures to leverage the collective intelligence of the city.
Washburn et al. (2010)	Smart cities use computing technologies to make their critical infrastructure, components, and services more intelligent, interconnected, and efficient.

Caragliu, del Bo, & Nijkamp (2011)	A city is smart when it invests in human and social capital, transport, and ICT to attain sustainable economic growth and a high quality of life through a wise management of natural resources and participatory governance.
Nam & Pardo (2011)	A smart city infuses information into its physical infrastructure to improve conveniences, facilitate mobility, add efficiency, conserve energy, improve the quality of air and water, identify problems, and fix them quickly, recover rapidly from disasters, collect data to make better decisions, deploy resources effectively, and share data to enable collaboration across entities and domains.
Thite (2011) GOV	Smart cities have a high quality of life, that pursue sustainable economic development through investments in human capital and communications infrastructure and manage natural resources through participatory policies.
Komninos (2011)	Smart cities are territories with high capacity for learning and innovation. Smart cities are based on the creativity of their population, their institutions of knowledge creation, and their digital infrastructure for communication and knowledge management.
Barrionuevo, Berrone & Ricart (2012)	Being a smart city means using all available technology and resources in an intelligent and coordinated manner to develop urban centres that are at once integrated, habitable, and sustainable.
Cretu (2012)	Smart cities do everything related to governance and economy using new thinking paradigms that are embedded in networks of sensors, smart devices, real-time data, and ICT integration in every aspect of human life.
Guan (2012)	A smart city is a city prepared to provide conditions for a healthy and happy community under challenging conditions that global, environmental, economic, and social trends may bring.

IDA (2012)	A smart city refers to a local entity like a district, city, region or small country that takes a holistic approach to employ IT with real-time analysis that encourages sustainable economic development.
Kourtit & Nijkamp (2012)	Smart cities are the result of knowledge-intensive and creative strategies that enhance the socio-economic, ecological, logistic, and competitive performance of cities.
Kourtit, Nijkamp & Arribas (2012)	Smart cities are cities that have high productivity as they have a relatively elevated share of highly educated people, knowledge-intensive jobs, output-oriented planning systems, and creative and sustainable initiatives.
Lazaroiu & Roscia (2012)	A smart city is a community of average technology size, interconnected and sustainable, comfortable, attractive, and secure.
Lombardi et al. (2012)	A smart city applies ICT on human capital/education, social and relational capital, and environmental issues.
Stratigea (2012)	A Smart City is a territorial system of innovations based on the cooperation of communities, clusters and regions.
Bakici, Almirall, & Wareham (2013)	A smart city is a high-tech, advanced city that connects people, information, and city elements using new technologies to create a sustainable, greener, competitive, innovative, and liveable city.
Batty (2013) INT	Smart cities can also be synonymous with intelligent cities, information cities, virtual cities, amongst many other nomenclatures, but here our usage pertains rather narrowly to data and theory that brings much more immediacy to our urban understanding.
Bonomi (2013)	The smart city project is an important appointment for Mediterranean Europe, because it allows for a reinvention of its territories, connecting the concept of “smart city” and “smart land”.

Zygiaris (2013)	A smart city is understood as a certain intellectual ability that addresses several innovative socio-technical and socio-economic aspects of growth.
Attour & Rallet (2014)	Smart city initiatives try to improve urban performance by using data and information technologies (IT) to provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration among different economic actors, and to encourage innovative business models in both the private and public sectors.
Benevolo & Dameri (2015)	Smart city development is not only a technical or economic issue but also involves the overall social system.
Dr.S. Musa (2016)	An urban development vision to integrate information and communication technology (ICT) and Internet of things (IoT) technology in a secure fashion to manage a city's assets.
Rosati & Conti (2016)	At first, it was thought that a "smart city" would be like a "digital city".
Komninos (2016, p. 197)	«new urban planning paradigm or set of business strategies rather than as an operating urban system»
Kourtit, Nijkamp, & Steenbruggen (2017)	Advanced ICT use in cities, with the aim to enhance efficiency (e.g. competitiveness) and sustainability (e.g. energy saving).
Kumar et al. (2018)	A city concentrating on the environmental, economic, and social aspects of urban life in competent, convenient, and cleaver way for attaining the quality of life with the amalgamation of intelligent and sustainable technologies.
March (2018)	The concept of Smart City encapsulates the desires and prospects on the transformative and disruptive role technology in solving urban issues.
Yun & Lee (2019)	The purpose of a Smart City is to solve its inherent problems while simultaneously reducing its expenditure and improving its quality of life.

Shea (2020)	A smart city is a municipality that uses information and communication technologies (ICT) to increase operational efficiency, share information with the public and improve both the quality of government services and citizen welfare.
Woods (2020)	Smart cities can be seen as the latest, and implicitly more efficacious, incarnation of the sustainable city.
Digital Transformation for People-Centered Cities (2022) Recommendation ITU-T Y.4900[5]	A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects.
Rosol & Blue (2022)	The term "smart city" is increasingly used to refer to urban developments that are enabled by Information and Communication Technologies (ICT).
Shafiullah et al. (2022)	The smart city concepts integrate information and communication technologies (ICT), collect information from various physical devices, and connect the citizens to optimize the operations and services efficiencies by utilizing the available resources for the wellbeing of the society.
European Comission (2023)	A smart city is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business.[6]

Source: *Own elaboration*

We may conclude that in general terms, the definitions on smart cities began with a higher focus on the technological dimension (e.g. Hall et al., 2000; Giffinger & Kramar; 2007; Dr.S. Musa, 2016), other authors focus on sustainability (e.g. Lazaroiu & Roscia, 2012; Bakici, Almirall, & Wareham; 2013; Woods 2020) on social issues (e.g. Yun & Lee,

[5] https://www.itu.int/cities/about/ accessed on the 2nd November 2024
[6] https://www.alter-solutions.com/articles/smart-cities-digital-revolution accessed on the 2nd November 2024

2019); economic issues (e.g. Attour & Rallet, 2014; Kourtit, Nijkamp, & Steenbruggen, 2017); governance issues (e.g. Shea, 2020) and finally some propose an integrated perspective of the previous dimensions (e.g. Batty, 2013; Recommendation ITU-T Y.4900[7]; Kumar et al., 2018).

The next topic provides a summary of the historical development of smart cities.

[7] https://www.itu.int/cities/about/ accessed on the 2nd November 2024

2. Historical development of smart cities

The development of smart cities has been described as a three-wave development.

The **first wave**, occurred in 1980s and witnessed a notable surge in the adoption of information and communication technologies (ICTs), particularly in the realm of information and transportation integration systems. Notably, cities like Sydney saw advancements in train signalling technology and the implementation of GPS-based on-axis location tracking. This era also witnessed the crystallization of the concept of intelligent cities, where various notions of desirable urban environments were discussed and aligned with global market trends. Concurrently, other urban concepts and typologies emerged, including competitive, creative, sustainable, resilient, and green cities. These developments signified a pivotal moment in urban planning and development, leveraging ICTs to enhance efficiency, safety, and overall quality of life in cities worldwide.

In the 1990s, the New Urbanism movement gained traction alongside the "smart growth" initiative and other trends advocating for strategies to render cities more compact, organized, sustainable, and community oriented. Pioneering examples of such urbanization endeavours include Cyberjaya and Putrajaya in Malaysia, as well as the Multifunction Polis in Adelaide, Australia. These cities leveraged ICT infrastructure to steer urban functionality and streamline processes through automation and optimization.

During this period, initiatives such as the Amsterdam Digital City project and the metropolitan area network in Geneva were initiated. Additionally, in the 1990s and 2000s, intelligent city initiatives surfaced in Australian cities like Brisbane and Blacksburg. These endeavours aimed to bolster social participation, facilitate access to information and public services, and combat digital exclusion through the integration of ICT. Overall, the 1980s witnessed a notable surge in the adoption of information and communication technologies in urban management.

In the **second wave** the term "intelligent city" became central. It emerged in 2005 with the purpose of the application of Information and Communication Technologies (ICTs) in addressing urban design challenges. Since its inception, it has become synonymous with technological innovations in the planning, development, management, and operation of urban areas. Major corporations including Cisco, IBM, Siemens, Microsoft, Huawei, Hitachi, Samsung, Telefónica, Oracle, SAP, and HP have embraced this concept, utilizing it to develop systems aimed at integrating and optimizing urban operations, infrastructure, and services.

The objective of this concept is to extend the reach of ICTs to as many urban areas as possible. These companies provide partnerships, consulting services, strategic planning, business analysis, metadata interpretation, software engineering, systems development, sensors, and other services. They also aim to build a portfolio of cities that have been transformed or improved through their intelligent solutions across various sectors, including buildings, transportation, and energy.

IBM was a pioneer in this context, transitioning from hardware to consulting and software services, while recognizing cities as an untapped market. They aspired to establish themselves as leaders in the deployment of intelligent urban technologies. However, differing corporate cultures and competing product lines prevented them from fully aligning on a unified vision of intelligent cities.

An analysis of 104 articles from periodicals indicates that prior to 2004, studies predominantly concentrated on the technological dimensions of intelligent cities. However, a significant shift occurred following the 2007 ranking of smart cities in European media, commissioned by the University of Vienna and Delft University of Technology.

By 2008, the surge in smart cities marked a turning point in their history, propelled by three key factors: the expansion of mobile bandwidth, the proliferation of internet-connected devices, and the growing urbanization of the world population.

The first point highlights the growing significance of mobile connectivity, epitomized by smartphones and other mobile devices, and the integration of new software and applications into citizens' daily lives. The second point emphasizes the expanding network connectivity among objects and within the everyday environment, encompassing sensors, digitization, cloud computing, the Internet of Things (IoT), and innovative services.

As cities started generating vast amounts of data, offering significant potential for enhancement, the integration of big data became closely linked with urban environments. This shift influenced decision-making processes and urban management practices, offering a novel source of insights into the functioning of cities and their developmental trajectories over time.

Over the years, the smart city has evolved into a competitive arena of "urban entrepreneurship," often with limited inclusion of ordinary citizens. This technologically deterministic approach to smart cities has been primarily spearheaded by major global technology companies in collaboration with city authorities. Literature produced by prominent ICT firms like Cisco Systems, Hitachi, and IBM has fuelled the proliferation of the corporate-driven smart city model. Consequently, the concept and implementation of smart cities have rapidly disseminated worldwide, catalysing the emergence of smart city initiatives globally.

The term has been applied to numerous innovations in urban planning, development, and operation. In 2011, the 'smarter cities' trademark was officially registered by IBM, marking a significant milestone in the competition among technology companies for recognition and credibility in the smart city market.

The concept of smart cities has continued to expand and develop beyond this timeframe. Various initiatives have been launched in different regions, such as the Covenant of Mayors for European Cities, aimed at reducing CO2 emissions by 2020. Additionally, the Europe 2020 strategy for smart growth advocates for investment in education, research, innovation, technology, resource management, and the transition

to a low-carbon economy. These efforts prioritize job creation and poverty reduction as integral components of sustainable urban development.

A significant increase in publications on the topic became evident around 2009, marking its establishment as a distinct field of scientific research. However, it wasn't until 2010 that a broader adoption of the term occurred, with an increasing number of studies incorporating smart city terminology.

In conclusion, since 2005, the term "intelligent city" has been employed to denote the utilization of ICTs for addressing urban design challenges and processing related information. It has come to encapsulate technological innovations driving advancements in the planning, development, management, and operation of urban areas. As cities undergo continual evolution, the significance of ICTs in urban planning and management is poised to further expand.

With the **third wave** the concept of intelligent cities has garnered considerable global attention and adoption, with numerous initiatives and research efforts aimed at evaluating the outcomes and maturity of such urban models. In the initial two decades of intelligent city research, there was significant hype surrounding the anticipated benefits of technological advancements. However, this enthusiasm was tempered by a subsequent decrease in expectations, prompted by disappointing results from early experiments. These experiments often adhered to principles such as technological determinism, a strong market focus, top-down development processes, and the "dupla hélice" model.

The current context involves a growing and competitive market for smart products and services, a vast network of smart cities, and a growing number of academic, professional, and government representatives collaborating to define the future urban landscape and promote the evolution of this model. Publications and academic studies related to this type of city have grown exponentially in recent years.

The European Commission's Agenda Digital initiative spearheaded the advancement of intelligent cities across Europe, alongside other efforts targeting energy-efficient urban development. In 2015, Japan introduced the i-Japan strategy, with the goal of fostering a digitally vibrant society. Similarly, Singapore unveiled its Intelligent Nation plan in the same year, alongside numerous other projects aimed at cultivating a smarter future.

Various countries have initiated practices to become intelligent cities, primarily to achieve their potential. For example, India declared its intention to build more than 100 intelligent cities, introducing high-tech technology throughout the country. China invested over 2 trillion RMB in smart cities between 2014 and 2016.

The adoption of intelligent technologies has helped transform public and private services, integrate sectors and functions, and provide real-time information, improving urban life and creating a new wealth stream in the economic area. However, negative effects and gaps in planning and execution have been noted, such as increased inequality, corporate control, the use of this model only as a marketing resource, the "fetishization of technology," the false view that this is the only effective method for urban transformation, and the lack of collaboration among different urban actors in its conception, implementation, and operation.

In the last three decades of the trajectory of intelligent city typology, the social sphere has been kept apart, with little direct influence on the development of intelligent cities. Local voices can contribute by expressing their needs and aspirations.

An integrated city concept, limited by technological determinism and corporate interests, has led to a market of solutions for intelligent cities that seeks to clarify the dominion and homogenize these solutions. It is essential that intelligent cities do not lose their cultural identity and historical product due to the homogenization of contemporary cities or the importation of international models that are not compatible with their characteristics and needs. Instead, they should value the unique characteristics that distinguish them from their counterparts.

In conclusion, the concept of intelligent cities has gained significant attention and inception worldwide. However, challenges remain, such as the increasing focus on technology and the need for collaboration among urban stakeholders.

The European Commission has supported the development of an intelligent city, with Santander becoming the largest IoT platform in the world. The city includes over 12,500 sensors for monitoring pedestrian numbers, parking volumes, waste containers, environmental aspects, and other applications, focusing on user responses to city services. Between 2012 and 2014, Santander installed around 2,000 sensors for environmental monitoring, hundreds of parking sensors, radiofrequency identification tags, and 60 traffic monitoring devices to analyse real-time city data.

The city has also utilized citizen science, or citizen science, which refers to the voluntary collection of all types of data. Initiatives include Santander City Brain, Portal Santander Open Data, Pulse of the City, and SmartSantanderRA, which provide information about 2700 locations in the city.

Cities can be considered intelligent only if they focus on their human and social capital, including communication and participation. To transform cities and ensure effective improvements in health, transportation, education, and services, a systemic view that integrates all sectors is necessary. Companies like IBM, Cisco Systems, and Siemens have criticized traditional approaches, arguing that technology can be used to train citizens and adapt their lives to technological demands. However, recent years have seen a new model that leverages the contributions and ideas of citizens, emphasizing the importance of community involvement and bottom-up knowledge in transforming the environment.

Desdemoustier, Crutzen & Giffinger (2019) describe two major ways to present smart cities: the first is a technological model, based on the products and services of technology companies, and the second is a holistic, humane, and sustainable model that can be considered a maturation of the first.

In the technological model, the question of the place and importance of technologies in the concept of smart city is a central discussion. The development of smart cities is measured by the deployment of sensors, grids and smart systems to improve the efficiency of local territories. In this approach, the focus is on the transformative power of technology, not relying on human contribution or to the human.

The second approach is people-oriented, as there seems to be an increasing consensus on the understanding that efficient and technological infrastructure is insufficient to make a city smarter. Batty (2012) points out that cities can only be intelligent to the extent that there are intelligence functions capable of integrating and synthesizing the results obtained with technological infrastructure with some objective involving efficiency, equity, sustainability, and quality of life in cities.

Authors such as Marek, Campbell & Bui (2017) call for the inclusion of citizen-led initiatives to complement top-down agendas for city development and management. Vanolo (2016) highlights the incoherence in conventional discourses of smart cities, where it is implicitly assumed that the projects will empower and improve the lives of citizens, but in fact place them in subordinate positions, leaving their voices absent, allowing technologies to limit their freedom and active citizens to operate as urban sensors.

The holistic approach, based on a broader perspective of the phenomenon, emphasizes the role of human infrastructure, human capital, and education in the development of cities. This approach encompasses a vision of a non-passive city, in a bottom-up management, considering citizens, organizations and businesses.

The management of intelligent cities is more complex than traditional cities, involving coordination among various stakeholders in different subsystems such as transport, education, and environment, in a single macrosystem that integrates Information and Communication Technologies (ICTs) into city resources. Intelligent cities are effectives, resulting from dynamic processes where public and private sectors work together on an

open platform for innovation to achieve common goals and co-create value for society's benefit.

The development of intelligent cities is an intensive activity in knowledge, with collaboration and collective action playing a central role. Urban problems can be solved through creativity, learning capacity, and collaboration among local actors. The concept of intelligent cities is primarily referenced in scientific literature from 2015-2018, referring to the social and human capital motivated to learn and participate in public life creation.

Cities that are humanizable, such as human-powered smart cities, can be viewed as human-oriented, incorporating technology in supporting soft infrastructure such as culture, justice, social capital, and human participation, ultimately improving the quality of life for citizens. However, research on the holistic approach to urban development remains preliminary and has not provided the necessary knowledge to understand how to apply theory to practice.

Technology represents a necessary condition but not sufficient for intelligent growth, and cooperation and participation among stakeholders are essential for the extension and utilization of ICTs and achieving the objectives of intelligent cities and territories.

The following table provides a summary of the three moments of the historic evolution of the smart cities' development.

***Table 2**: Three moments of historic evolution*

Waves	First wave	Second wave	Third wave
Characteristic	Dismantled	Corporativist	Humanized
Decade	The 80s and 90s	The 2000s and mid 2010s	Current period
Emphasis	The convergence of new theories and policies in urbanism and the spread of ICTs in cities. Diffuse focus.	Directed by the interests of large technology companies. Focused on technology.	Driven by the needs and desires of citizens and communities. Focused on people.

***Source:** Adapted from Depiné & Teixeira, (2021)*

The next topic provides a description of the most recognized and mentioned models of smart cities.

3. Models of smart cities

After the conceptualization and an approach to the evolution of the smart cities concept(s) the interest is centred in the characterization of the dimensions of the concepts. In this topic are described some of the most recognized, mentioned and relevant models of smart cities.

3.1 IDM Smart City Index, 2023

The initial endeavour to create what could become a globally recognized smart city index is divided into two phases with separate deliverables. First, a series of case studies of smart cities at various stages of development, giving a wide international base of experience, with the goal of improving the realism and relevance of the model that would support the proposed index.

Since 2019, the International Institute for Management Development (IMD) has developed a Smart City Index featuring a balanced focus on five dimensions throw smart structures and technologies.

The following dimensions are divided in structures and technologies, even though these five dimensions belong to both components.

***Table 3**: The dimensions of IMD Smart City Index, 2023*

	Structures	Technologies
Health & Safety	Affordable housing Air pollution Basic amenities Health services Recycling Security	
Mobility	Public transport Road congestion	
Activities	Citizen engagement Green spaces	
Opportunities (Work & School)	Fulfilling employment School education	

	Unemployment
Governance	Corruption Social mobility

Source: Adapted from (Smart City Observatory, 2017).

According to this model the top 5 smart cities are: Zurich, Oslo, Camberra, Copenhagen, Laussagne.
https://www.imd.org/smart-city-observatory/home/ accessed in April the 1st 2024

3.2 Giffinger et al. (2012) and Batty et al. (2012)

Two important works (Giffinger et al, 2012, and Batty et al, 2012) were a reference in relation to fix the dimensions that characterize a smart city: Governance, Community, Economy, Mobility, Environment and Quality of life.
A brief description of each dimension follows.

Governance

According to Fukuyama (2013) governance is "the ability to make and enforce rules, and to deliver services, regardless of whether that government is democratic or not".
Alonso & Lippez-De Castro (2016) and Albino et al. (2015) argue that governance evolves participation and cooperation of various stakeholders in the process of making decisions.
The government should also modernize administrative processes and coordinate all five dimensions of a smart city, making it an essential factor in the success of smart cities (Rodrigues et al., 2018).

Community

Cambridge Dictionary (2019) says the meaning of community is the "people living in one particular area or people who are considered as a unit because of their common interests, social group, or nationality".

The sense of community is important to acquire individual's skills and proficiencies to form their own opinions and attitudes through participation in a democratic process (Mezirow, 1963).

For example, in Canada, the City of Guelph conducted community consultation for the Smart City Challenge, involving various stakeholders such as business community, social, education, and agriculture sectors, and technology experts. The consultations took place over nine months, involving small groups and one-on-one meetings. The approach was categorized as "Involve" on the IAP2 spectrum, focusing on face-to-face meetings and online platforms (Goodman *et al*., 2020).

Economy

The economy is a system for producing, distributing, and consuming commodities and services. There are several sorts of economies, including command, traditional, market, and hybrid. Each has different ideals and ways of control. Economies are not created in a vacuum. These restrictions, or regulations, are set by conventions or laws enacted by people in power typically a government and apply to individuals, companies, and governments.

For economic development to occur in cities, cities can foster startups and entrepreneurship by providing conducive environments, such as incubators, accelerators, and coworking spaces. This can attract investments and talent, creating jobs and fostering innovation. Digital infrastructure is crucial for a city's development, allowing high-speed internet access and the use of technology. Cities can also promote clusters of innovation, focusing on specific sectors, to attract talent and investment. Public-private partnerships can incentivize economic development and innovation in a city. Education and technology training are essential for supporting businesses and innovation initiatives (National Geographic, 2024)[8]

In the framework of an intelligent industry, the concept of IoT is used to develop intelligent products that allow continuous monitoring throughout the product's life cycle and collect, store, and send data amongst themselves and to citizens. Other related concepts include the Internet of Services, which combines intelligent transportation and

[8] https://education.nationalgeographic.org/resource/resource-library-economy/ accessed on the 25th April 2024

logistics, and the Internet of Energy, which determines how and when natural resources should be used (Lom et al., 2016).

Therefore, it's important to relate economy with urbanism and new technologies used among the cities.

Mobility

Mobility is "the ability to move or be moved freely and easily" or in another context "the ability to move between different levels in society or employment" (Oxford Languages, 2024).

In all smart cities, it's meaningful to mention the mobility related with transportation within sustainable mobility. Among the transportation there are very issues to include in sustainable mobility for instance car sharing models, electric cars and flight vehicles (Mavlutova et al., 2023). About technology, advanced sensor networks can detect road accidents and manage traffic flow, providing real-time information and increasing safety for users of transportation.

A smart mobility system has a direct economic benefit by transporting people resources to their workplaces. And the environment due to the damaging pollutants from automobiles and, as a result, the community's quality of life (Singh et al., 2015).

Environment

The term "environment" refers to all living and non-living components, as well as their effects on human existence. Animals, plants, forests, fisheries, and birds are all examples of living or biotic components, whereas water, land, sunshine, rocks, and air are non-living or abiotic.[9]

Growing population and maximum utilization of natural resources in cities produce ecological and environmental concerns, as well as public disturbance problems (Haughton, 1997).

As a result, technological development as Armbrust et al. (2010) includes three main components, evolving the ICT (Information and Communication Technology), Big Data and IoT (Internet of things). The same authors also said the Information and

[9] https://byjus.com/commerce/meaning-and-functions-of-environment/ accessed on the 24th April 2024

Communication Technology (ICT) revolution has transformed urbanization by making city systems more digital and information based. This has led to a significant change in citizens' living environment and governing mode. ICT has integrated various aspects of cities, including economy, culture, transport, and entertainment. Innovative technologies like cloud computing, big data, data vitalization, and mobile computing have become widely adopted, enabling more efficient internet services.

Quality of life

Jenkinson (2024) describes quality of life as something “highly subjective” and “inherently ambiguous”. because it can apply both to the experience that an individual has in his or her own life and to the life situations in which individuals find themselves.

The cities may give us different experiences regardless of whether they are a better or worse experiences as knowing persons and the people’s behaviour (environment) or even if we talk about activities, events, parties, concerts and/or everything else. It’s also important to mention experiences about if any person or a community lives in a cozy house and/or can get access to get health or money to buy healthier products (food, medications, beauty products as skincare products, etc) or even when we talk about pollution, waste management and/ or water potability for instance.

All these things are important to link the quality of life with the city.

Most studies include a great variety of indicators on subjects such as health, housing, job, leisure, and crime, but in the end, what they indicate is that the quality of life cannot be objectified since these indicators, their representation, and interpretation inherently entail some type of judgment (Loetscher, 1985).

However, according to Quality of Living City Ranking 2023 considering water potability, waste removal, sewage, air pollution, water availability and traffic congestion.

The top 3 of these ranking is Vienna (capital of Austria), Auckland (city in New Zeland) and Zurich (city in Switzerland), at the order from the top to below, meanwhile the 3 worst cities are Khartoum (capital of Sudan), Baghdad (capital of Iraq) and Bangui (capital of Central African Republic), respectively, starting from the bottom up.

3.3 IESE Cities in Motion Index 2024

IESE - Instituto de Estudios Superiores de la Empresa of the University of Navarra in Spain developed an index known as IESE Cities in Motion Index 2024. According to it the dimensions that characterize a smart city are nine: Human capital, Social cohesion, Economy, Governance, Environment, Mobility and transportation, Urban planning, International profile and Technology.

Taking this model into account the top 5 smart cities are London, New York, Paris, Tokyo, Berlin.

The following table summarizes the main dimensions of IESE.

***Table 4**: Main dimensions of IESE*

	Main dimensions of IESE 2024								
	Human capital	Social cohesion	Economy	Governance	Environment	Mobility and transportation	Urban planning	International profile	Technology
Indicators	Secondary and higher education	Female-friendly	Unicorn companies	Bitcoin legal	CO2 emissions	Bicycle, moped or scooter rental service	Bicycles	Number of passengers per airport	Mobile broadband
	Schools	Hospitals	Ease of starting a business	ISO 37120 certification	Methane emissions	Bike sharing	Bike Advance	Hotels	Innovation Cities Index (ICI)
	Business schools	Crime rate	Global Startup Ecosystem Index (GSEI)	Government buildings	Environmental Performance Index	Metro stations	Buildings	Restaurant Price Index	Internet
	Expenditure on education	Slavery Index	Mortgage	Embassies	CO_2 Emission Index	Traffic Inefficiency Index	Electric charging stations	McDonald's	Computers/PCs
	Expenditure on leisure and recreation	Happiness Index	Motivation for individuals to undertake early-stage entrepreneurial activity	Public sector employment	Pollution Index	Traffic and congestion index	Percentage of the urban population with adequate sanitation services	Number of congresses and meetings	Mobile phone penetration rate
	Expenditure on leisure and recreation per capita	Gini Index	Number of company headquarters	E-Participation Index	PM10	Exponential traffic Index	Artificial intelligence (AI) projects		Social media platforms
	Student mobility	Global Peace Index	Number of Fortune 500 companies	Human Capital Index	PM2.5	Metro lines	Percentage of high-rises		Broadband subscriptions
	Museums and art galleries	Health Care Index	GDP	Strength of legal rights index	Percentage of population with access to water supply	Length of metro system	Traffic accident mortality rate		Telephony
	Number of universities	LGBTQ+ friendly	Estimated GDP	Telecommunication Infrastructure Index	Renewable water resources	Percentage of households with bicycles			Internet speed
	Theaters	Price of property	GDP per capita	Corruption Perceptions Index	Solid waste	High-speed train			Mobile speed
		Female employment rate	Purchasing power	Online Service Index	Climate vulnerability	Vehicles in the city			WiFi hotspots
		Death rate	Productivity	Research offices		Flights			
		Unemployment rate	Hourly wage in US dollars	Open data platform					
		Murder rate	Time required to start a business	Democracy Index					
		Suicide rate		Reserves					
		Terrorism		Reserves per capita					
		Racial tolerance							

Source: Adapted from Mavlutova et al. (2023).

3.4 Shen et al. (2018)

According to these authors the dimensions that characterize a smart city are five: Smart Infrastructure, Smart Governance, Smart Economy, Smart Environment and Smart People.

A brief description of each follow.

Smart Infrastructure

Weiss (2009) defines smart infrastructure as a lens through which the future is viewed. It refers to self-driving automobiles that recognize one another, bridges that detect their own flaws, power grids that communicate data with household appliances, and all cyberphysical infrastructure systems that make cities smart.

In the context of smart cities, Alkandari et al. (2012) defines smart infrastructure as the backbone of a city, driven by a wireless sensor network.

Smart infrastructure is crucial for the development of smart cities as it enables efficient management of urban infrastructures. In the context of smart cities, smart infrastructure integrates advanced technologies like ICT and IoT to enhance the functionality and sustainability of urban systems. By optimizing infrastructure design and deployment, smart cities can improve services, reduce energy consumption, and enhance overall quality of life for residents (Ota *et al.*, 2017).

Smart Governance

Smart Governance, also known as smart e-governance, is defined by IGI Global as the "use of technology and innovation to facilitate and support enhanced decision-making and planning within governing bodies". It is frequently related with enhancing democratic procedures and modifying how public services are delivered.

A smart government is supposed to foster collaborative settings and encourage cooperation between the government, other external organizations, and people (Nam and Pardo, 2014).

After consulting with experts in local municipality decision-making bodies, we found that various factors might support, impede, or create hurdles to smart governance solutions. Cost, like with everything else, is crucial when deploying a smart governance solution.

This is closely followed by infrastructure and Technology. Smart Government solutions provide long-term cost savings by simplifying services, either internally or externally[10].

Smart Economy

IGI Global describes smart economy as an economy that uses technical innovation, resource efficiency, sustainability, and high social welfare to drive success. It promotes innovation and new entrepreneurial activities while increasing productivity and competitiveness, with the main objective of enhancing the quality of life for all citizens. Most scientists associate the term "Smart Economy" with a specific system, such as smart cities.

Smart Economy refers to an economic system that prioritizes using cutting-edge technology, implementing sustainability and social responsibility principles, and ensuring citizens' comfort and safety. The Smart Economy functions as an ecosystem with balanced primary components. Smart Economy creation involves six important processes: intellectualization, digitization, greening, socializing, institutionalization, and urbanization (Kalenyuk I. et al, 2021).

Smart Environment

Smart environments aim to enhance the comfort and experience of inhabitants by replacing hazardous work, physical labour, and repetitive tasks with automated agents (Ryan et al., 2023).

For Kumar (2020) “the smart living that conserves environment is the answer to the smart environment”.

Poslad (2011) differentiates three kinds of smart environments, divided by virtual computing environments, physical environments, and human environments. The first one enables smart devices to access important services from anywhere and at any time. Physical environments may be embedded with a range of smart devices of different sorts such as tags, sensors, and controllers and have varied form factors ranging from nano-to micro-to macro-sized. This last type, human environments simply means human beings, individually or collectively, who are those who naturally create an intelligent

[10] https://www.hlp.city/smart-governance-a-hybrid-of-civic-technology-iot-and-local-government/ accessed on the 22nd April 2024

environment for electronics. However, people can be accompanied by smart devices such as mobile phones, employ surface-mounted devices such as a wearable computer, for example, or have embedded electronics.

According to Nexus Smart City, smart environmental solutions include smart systems that manage environmental quality, irrigation, garbage, photovoltaics, lighting, weather stations, and water supply. The goal is to increase energy efficiency and environmental quality in cities.

Smart People

According to Arguys (2002) being a smart person is not only about solve problems, but also about the need of to reflect critically on their own conduct, understand how they frequently unintentionally contribute to the organization's issues, and then modify their behaviour. They must understand that their approach to problem-solving might create difficulties in and of itself.

The conscientiousness dimension is a measure of dependability. A highly conscientious individual is less distracted and more organized, reliable, trustworthy, eager to learn new things, and persistent. People who take better care of themselves tend to have longer lives. Paying attention to their surroundings and behaving accordingly are critical components in the success of smart people in a certain smart city. This personality component can help to establish a safe, secure, crime-free, and healthy environment in a smart city (Kapoor, 2017), According to this model in China the top 5 smart cities are Senzhen, Beijing, Guangzhou, Shanghai, Hangzhou.

3.5 Juniper Research (2024)

> *A smart city is a place where traditional networks and services are made more efficient using digital solutions for the benefit of its inhabitants and business. It means smarter urban transport networks, upgraded water supply and waste disposal facilities, and more efficient ways to light and heat buildings.* (Juniper Research, 2024)[11]

[11] https://cities-today.com/berlin-named-as-europes-smartest-city-thanks-to-maas/ accessed on the 23rd February 2024

According to the authors the dimensions that characterize a smart city are four: Transportation and infrastructure, Energy and lighting, City management and technology, Urban connectivity.

To characterize a smart city, it was necessary to make this classification based on these previous four aspects. The ranking evaluated factors such as the deployment of innovative technologies like 5G, digital twins, and smart grids, as well as the efficiency of city services provided to residents through platforms like Suishenban Citizen Cloud. Cities leading in these areas and effectively utilizing data and connectivity to enhance citizen experiences were ranked higher in the evaluation. Cities also excelling in these areas and leveraging data and connectivity to improve citizen experiences were positioned higher in the rankings, showcasing their leadership in smart city innovation and development.

According to this model the top 5 smart cities are Shanghai, New York, Toronto, Seoul, Shenzhen.

3.6 Integrative approach used in Guimarães

Considering the information collected from the Guimarães municipality website, papers collected from the web and from information gathered within the scope of the internship that the author developed in the Guimarães municipality, it was concluded that, inspired in the previous models, Guimarães defines nine dimensions to develop the city. They are characterized as follows:

3.6.1 Connectivity

Guimarães Wi-Fi is a free internet network that requires user registration and is a promising invention for people and metropolitan areas. The project aims to establish cutting-edge Wi-Fi network solutions in metropolitan areas, making them accessible to both locals and visitors. Guimarães Wi-Fi established 23 hotspots in phase one to cover public interest places. In phase two, they want to add 20 more hotspots to cover other regions and expand to 9 villages.

3.6.2 Mobility

"Guimarães à Boleia" is a free car sharing platform that aims to contribute to a better environment and shape the future of transportation. It allows users to gain short-term access to transportation on an as-needed basis, allowing citizens significant savings in mobility costs and several benefits. This includes reducing transportation costs, decreasing time spent finding parking, and allowing fewer cars to circulate on roads.

3.6.3 Energy efficiency

With the process of developing a Smart City strategy, to be presented within the scope of H2020, Guimarães intends to leverage energy efficiency projects, like DREAM application that aims reduction of the use of fossil fuels, use of smart grids, efficient public lighting, among others, helping our city to develop and build on its strategic priorities (Costa et al., 2019).

Guimarães Is a Pilot City in European Decarbonization Project[12] In line with this the municipality began installing LED technology in street lighting in 2015 with the aim of achieving a 100% LED technology in street lighting within 25 years.

3.6.4 Citizen participation

Participatory budget is a platform that contributes to an informed, active, and responsible engagement of citizens in local government processes, facilitating the participation of residents and civil society groups in the decision to allocate money to municipal public policy (Costa et al., 2019).

3.6.5 Waste management

The so called "Zero Waste Certification" will make Guimarães a better sustainable city. Guimarães municipality subscribed it on a European scale, supported by the European

[12] https://peggada.com/en/guimaraes-is-a-pilot-city-in-european-decarbonization-project/ accessed on 15 April 2024

non-profit organization Mission Zero Academy (MiZA), led by Zero Waste Europe and ZERO - Sustainable Earth System Association.

By 2030, this approach intends to reduce trash output, increase reuse, household composting, and community composting, and develop a more effective and efficient selective collection system. With this strategy, residents will share responsibility for local trash management, resulting in a larger and more active commitment to increasing recycling and minimizing the generation of undifferentiated garbage.

3.6.6 Health and wellbeing

Guimarães could become a healthier city due to environmental measures and the construction of parks and recreational activities, even if there are clinics and hospitals that work minimally well.

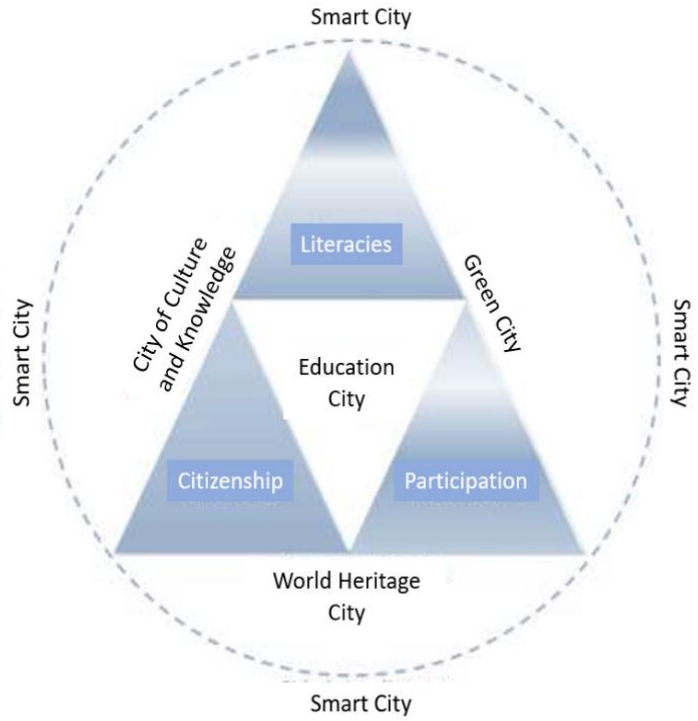
3.6.7 Digital education

In the educational dimension, in participatory budget for schools, students can decide in a democratic process what they want to improve in their school (Costa et al., 2019).

According to the Educational Program provided by the municipality[13], education is a project, unfinished and incomplete, aimed at the integral formation of everyone, so that the territory of Guimarães is exploited as a means of producing and articulating knowledge, in the realisation of an image of a city that is intelligent through the creative and critical participation of all. Guimarães will be even more intelligent if the strategic principles of education - literacy, citizenship and participation - are taken on board, as envisaged in the Guimarães Citizen Education Project, in the context of a green city, a heritage city and a city of culture and knowledge (see figure below)

[13] https://www.cm-guimaraes.pt/cmguimaraes/uploads/writer_file/document/6780/plano_de_educacao_municipal.pdf accessed on 4 May 2024

***Figure 1**: Pillars of the Educational Project of Guimarães*



Source: Adapted from https://www.cm-guimaraes.pt/cmguimaraes/uploads/writer_file/document/6780/plano_de_educacao_municipal.pdf

3.6.8 Security

According to the citizens, Guimarães is generally safe and public security, and laws work well. Crime occurrences are more frequent at night and the most common crimes are drug trafficking and theft (Teixeira, 2018)

3.6.9 Smart Tourism

Guimarães Mobitur is a mobile application that accompanies visitors in a visit to the city of Guimarães. With a radar navigation based on the current location, it provides a selection of points of interest and events in an interactive and different way. The new already in progress version will perceive the movement of users in physical space, integrating time-based georeferenced data monitoring framework providing a powerful

tool in the decision-making processes of analysis, planning and tourism management (Anacleto et al., 2014).

Guimarães has been mentioned in foreign press as a “city with a creative edge” and considered one of the most beautiful cities in Europe.[14]

There are some other projects to improve Guimarães as a smart city as a construction of a pedestrian trail along the banks of the main watercourse; the Guimarães' Green Brigades, an element recognized by the European Union, in transforming community attitudes and behaviors in favor of environmental sustainability. Guimarães currently (September 19, 2022) has 33 Green Brigades, with the aim of reaching all 48 parishes in the municipality, in order to encourage and recognize good environmental practices in the area; and the "Bairro C - Caminhos de Cultura e Criatividade" project aims to "structure itself in the area connecting Couros, Caldeiroa and Avenida Conde Margaride as a 'laboratory of ideas' based on the pillars of Culture, Creativity, Knowledge and Science". It also aims to be "a space for innovation and experimentation, both from a technological point of view and with new aesthetics and artistic languages, offering new readings on the relationship between the city, artistic creation and the community". It's planned for three years. It includes the commemoration of 20 years of UNESCO Cultural Heritage and concludes with a reference to 10 years as European Capital of Culture (CM Guimarães, 2022).

[14] https://metro.co.uk/2024/09/10/portuguese-city-a-creative-edge-one-europes-beautiful-hotels-40-21573375 accessed on 8th September 2024

4. Examples of smart cities

During this dissertation/report, some of the most proficient examples of smart cities will be presented, yet, considering the analysis object of this research we will also provide some comparable, less proficient examples. This approach is presented because the analysis object of this thesis is Guimarães, a town with some particularities in terms of dimension (small) and geo-social characteristics that demand a different approach more connected with what the literature names as Pilot Cities. Pilot cities are cities that have committed to implementing projects and strategies to achieve climate neutrality by 2030 (Monteiro & Ferreira, 2023). As result, although the most proficient smart city models are described they will be considered less relevant to this research.

Related to the specific features of Guimarães, some twin cities will also be mentioned. Twin cities differ from other municipal units for they are adjacent geographically; they have a common history from a time when they were each a single entity. Despite the history of shared frontiers, at the present stage, twin cities are administratively divergent, institutionally independent but economically linked. (Luo et al. 2023)

The criteria to select the description of the following smart cities models considered by one hand the smart cities index 2023 and by another hand the fact that some cities are part of the European Pilot Cities program because they were more comparable to Guimarães in terms of socio-demographic characteristics.

4.1 Smart cities provided from the smart cities IDM Smart Cities Index 2023

Here are summarized some of the most important smart cities provided by the IDM Smart Cities Index 2023. A more extensive description is provided in the end of this dissertation/report in the annexes part.

The following table provides a brief description of each smart city selected from the Smart Cities Index 2023.

***Table 5**: Summary of the selected smart cities from the Smart Cities Index 2023*

Smart Cities	Brief description
Zurich	Zurich was ranked in the first place in the last 4 years by Smart City Index Report (2023), thus considering the smartest city in the world. The municipal council fortifies and expedites the digital transformation of the city administration with the strategic emphasis Digital City (2019).
Oslo	The Norwegian capital was awarded the European Green Capital 2019 title by the European Commission and ranked at the second smartest city in the world over the last 4 years according IMD Smart City Index Report 2023.
Canberra	The ACT Government is committed to transforming Canberra into a smart and connected digital city. To guarantee that Canberra continues to be the most liveable city in the world, the ACT Government's smart city initiative makes use of smart partnerships, smart policies, and smart technology.
Copenhagen	"The green growth city" Copenhagen's smart city plans are aimed at being carbon neutral by 2025.
London	The smart city initiatives of London are organized under the Smart London platform, directly under the governance of the mayor of London.
Singapore	Singapore belongs to the top seven smartest cities in the world and the best in Asia according to IDM Smart City Index Report 2023.
Helsinki	Helsinki, named the European capital of smart tourism in 2019, boasts the best digital twin, the most innovative region, the best European mid-sized region for foreign investments, and the fifth and eighth best smart city globally.
Hamburg	The Smart City Lab in Hamburg focuses on local district management services for energy, mobility, and public involvement.
Stockholm	Stockholm as a smart city launched the Stockholm Smart City Conference & Expo for May 22 and 23, 2024 to business executives, entrepreneurs, professionals, authorities, politicians, decision makers, and academics from around the Nordic countries convene to learn from one another, exchange experiences, discuss best practices, and explore new avenues for international collaboration.

Amsterdam	Amsterdam Smart City focuses on a smart, green, and healthy future for the Amsterdam Metropolitan Area, focusing on a values-first approach and utilizing data and tech to improve quality of life.
Seoul	Seoul, the capital of the Republic of Korea, achieved a high score in the McKinsey Global Research Institute's 2018 review of smart city technologies.
Dubai	The emirate's seventh development plan since 1960 is the Dubai 2040 Urban Master Plan. Dubai's population expanded from 40,000 in 1960 to 3.3 million in 2020, an 80-fold rise, while the emirate's built-up area increased from 3.2 square km to 170-fold.
Hong Kong	The "Hong Kong Smart City Blueprint 2.0." acts as a communication link between the government and the public, delivering real-time city data dashboards and information on smart city projects. Initiatives include the implementation of new electronic payment systems, real-time traffic signal systems, crowd management systems, and smart recycling initiatives.
Vienna	Vienna's urban development history has contributed to the city's exceptional quality of life.
Barcelona	Barcelona, a city more than 2,000 years old, provincial, and marginal, without the capital of an important monarchy or state, with practically no public spaces, walls and an extremely dense grid, a style of urban planning common in the Middle Ages.
Rotterdam	The case focuses on platform purpose, governance, finance, trust, and citizen involvement via the OUP (open urban platform) by city management, as well as the opportunities for innovation in this Dutch city.
Tokyo	Tokyo hosted its first global smart cities event, City-Tech Tokyo, in February 2023.
Melbourne	In Melbourne, the City of Casey has had a smart city strategy in place since 2017
New York	The smart city journey in New York City (NYC) began in 2007 with the vision set by PlaNYC for NYC through 2040. Data collection across ten focus areas such as energy, climate change, and air quality started to improve policy.
San Francisco	San Francisco is renowned for its innovative technology and smart city initiatives.
Osaka	Plug and Play, a global venture accelerator, has expanded to Osaka to address social issues such as demographic structure, building revitalization and natural disasters

Abu Dhabi (Masdar)	The Masdar Smart City is located just a stone throw away from Abu Dhabi (capital of United Arab Emirates). This city intends to become "the first zero carbon city in the world".
Cairo /New Cairo City)	The New Cairo capital city is 35 kilometres east of Cairo and covers a total area of 725 km2. The new capital is located between the regional ring road, Cairo-Suez and Cairo-El Ain El Sokhna Roads. It is a city designed for 6.5 million inhabitants.
Medellín	Medellín was considered as the best innovative city for the year 2012

Source: Own elaboration

Because most of these smart cities are not comparable with the analysis unit of this research – Guimarães – in terms of geographical dimension, number of inhabitants and other relevant features, and because there are other smart cities` projects that are not included in this index we decided to investigate and describe by one hand the most relevant projects and by another the smart cities collected from pilot studies because we considered them more comparable to Guimarães regarding geographical dimension, number of inhabitants and other relevant features.

The next sub-topic concerns other relevant smart cities' projects.

4.2 Other relevant smart cities` projects

There are other smart cities that are not considered in the IDM Smart Cities Index 2023, yet they are often mentioned in the literature. We provide here a brief description of some of them.

4.2.1 Incheon/Songdo (Southern Corea)

The Songdo New Town project was initiated in 1987 and designated as part of an economic recovery strategy after the 1998 East Asian economic crisis. In 2002, New Songdo International City LLC was established by Gale International and POSCO. Songdo has been characterized as a business hub, free economic zone, eco-city, and smart city. The development aimed to create a mixed-use area with diverse facilities such as office

buildings, schools, museums, and residential buildings. Although the completion was initially planned for 2015, it faced delays due to various factors. The delays in the completion of the Songdo project were influenced by various factors such as the 2007 financial crisis, government policies, and challenges posed by the high smartphone ownership rate in Korea affecting the planned smart services in Songdo U-Life (Huh et al., 2024).

4.2.2 Neom/The Line (Saudi Arabia)

The NEOM project was announced on October 24, 2017, by Crown Prince Mohammed bin Salman at the "Future Investment Initiative" conference in Riyadh, Saudi Arabia.
The Line is in Saudi Arabia, especially in the NEOM project region. It covers a 170-kilometer tract of land in a coastal desert region, acting as a link between the project's north and south. The Line is intended to connect four unique ecologies, including exotic nature and natural reserves that stretch to the southeast of Neom and beyond the Red Sea islands.
The goals of The Line project in Saudi Arabia include building around nature to create hyper-connected communities, transforming urban life by creating a sustainable and regenerative environment, boosting economic diversity to attract investors and create job opportunities, providing easy access to essential services within a five-minute walk, implementing high-speed transportation supported by artificial intelligence, creating a city without roads and cars to reduce congestion and pollution, connecting distinctive ecologies and preserving 95% of the natural world within NEOM, and establishing a million-person city with no vehicles, highways, or carbon emissions (Al-sayed et al., 2022).

4.2.3 Brazil high tech parks

In Brazil, innovation ecosystems such as tech parks, coworking spaces, and incubators are critical to encouraging innovation and information exchange. These areas help to create smart and sustainable cities by integrating smart infrastructure with high-density, mixed-use projects. The legal forms of technology parks, which can range from private

groups to public corporations, influence their potential to offer favourable conditions for innovation. Tech parks in regions with adequate connectivity and access to amenities promote sustainable urban development by serving as hubs for innovation and cooperation. Overall, Brazilian technology parks have the potential to play an important role in promoting smart and sustainable urban development (Costa & de Matos, 2020).

4.2.4 Tampere (Finland)

Tampere's smart city projects have evolved since at least 2014. Tampere, with a population of more than 213,000, has established itself as Finland's major industrial city. The Smart Tampere initiative demonstrates the city's approach to smart city development, which focuses on combining technical, human, and organizational variables to improve sustainability on social, economic, and environmental levels.

Tampere's smart city policy places a high focus on collaboration with a wide range of stakeholders, including academics and corporate groups. Tampere's municipal administration has the authority to establish strategic goals in the areas of smartness and sustainability that are consistent with national policies and guidelines.

Tampere's Digitalization, Ecosystem, and Sustainability initiatives seek to foster collaboration among many city actors to accomplish digitalization, solution development, and sustainability goals. The city's emphasis on public interaction and collaboration with businesses demonstrates its dedication to inclusive and sustainable smart city development.

Overall, Tampere's approach to smart city projects is a paradigm for progressive policy development and good public governance in the field of urban smartness (Grossi & Welinder, 2024).

4.2.5 Yokohama (Japan)

The Yokohama Smart City Project, initiated in 2010, is a comprehensive initiative by Yokohama City in Japan to transform the city into a sustainable and technologically advanced urban environment. The project focuses on reducing greenhouse gas

emissions, promoting renewable energy sources, and implementing innovative energy management systems.

One of the key components of the Yokohama Smart City Project is the Demand Response Demonstration, which involves various initiatives led by prominent Japanese business entities. These initiatives are cantered around six technological pillars: Community Energy Management System (CEMS), Building Energy Management System (BEMS), Factory Supervisory Control and Data Acquisition (FEMS), Home Energy Management System (HEMS), Supervisory Control and Data Acquisition (SCADA), and Electric Vehicle Energy Management System (EV-EMS).

The project also involves collaboration with 34 institutions, including companies like Nissan, Panasonic, Toshiba, Tokyo Gas, Tokyo Electric Power, and Accenture. These partnerships aim to implement a variety of technical and social systems related to smart technology in Yokohama.

Furthermore, the Yokohama Smart City Project serves as a testing ground for new technologies and innovative solutions. It allows participating industries the flexibility to choose project locations, such as implementing BEMS projects in shopping malls and supermarkets. The project has gained significance following the Great Eastern Japanese Earthquake in 2011, as public interest in energy efficiency and smart technologies has increased.

Overall, the Yokohama Smart City Project showcases Yokohama's commitment to sustainability, technological advancement, and international collaboration, with the goal of exporting its smart city model to developing countries as an infrastructure package (Suwa, 2020).

The following sub-topic provides the context of the smart cities collected from Pilot Studies.

4.3 Smart Cities collected from Pilot Studies

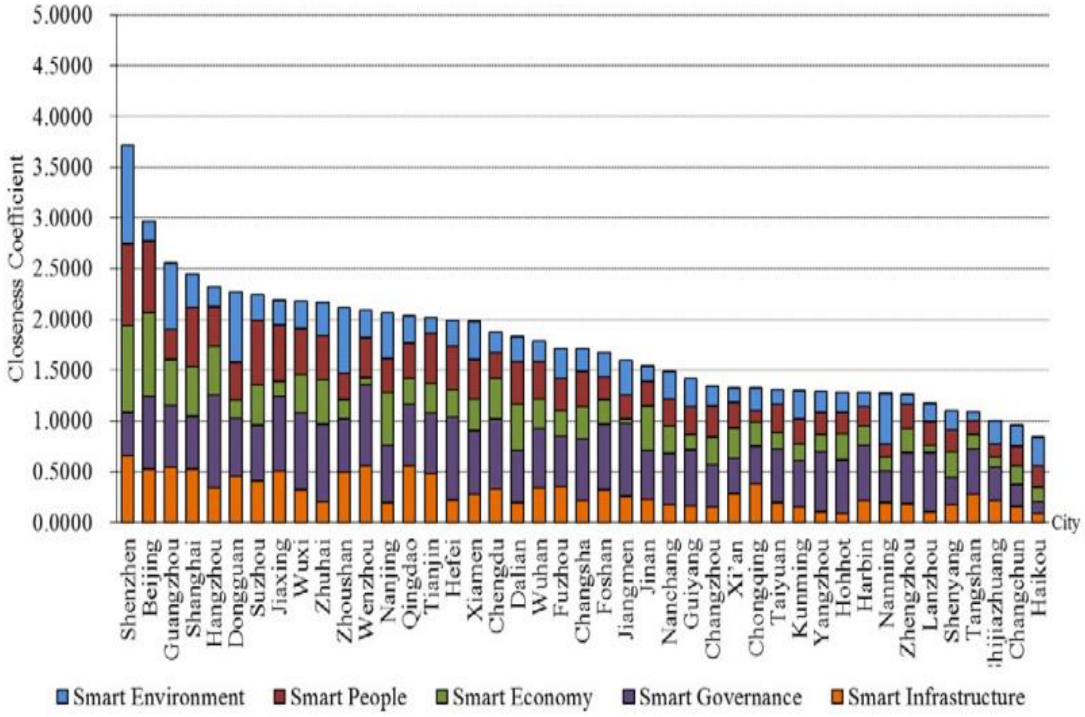
Considering its specific characteristics, Guimarães will be compared with comparable smart cities collected from Pilots Studies developed with European Unions` smart cities.

Nevertheless, a brief overview of pilot studies developed in China are provided here before.

In China, there are 44 pilot cities. The Chinese pilot cities serve as key examples in the promotion and development of smart cities. These cities aim to showcase successful implementation of smart city programs, focusing on enhancing various aspects such as infrastructure, governance, economy, people, and the environment. By serving as models of effective smart city practices, the pilot cities aim to share their experiences and best practices with other cities in China. This sharing of knowledge is intended to help improve overall smart city performance across the country. The ultimate goal is to create a sustainable and balanced development across different dimensions of smart cities, ensuring long-term success and innovation in urban environments.

In the table below, it's possible to analyse and compare the smart performance among 44 pilot studies launched in China.

***Table 6**: The overall smart performance between the 44 Chinese pilot smart cities*



Source: Shen et al. (2018).

There are other relevant projects in this country. Smart cities and smart industrial parks in China leverage ICT technologies to optimize resource management, promote clean energy adoption, and tackle climate change challenges. Policy initiatives like Circular Economy, Eco-City, Low-Carbon City, and Ecological Civilization Demonstration Region are implemented to enhance urban sustainability and liveability. China's approach to smart cities promotion stands out for its national scale and comprehensive integration of innovative technologies and strategic measures in policy implementation. A comparison with international practices underscores China's significant social impacts and holistic system development. The use of monitoring data and low-carbon monitoring systems supports efforts to mitigate climate change and informs the design of a low-carbon pathway (Wang et al., 2019).

According to NetZeroCities, Pilot Cities represent the beginning of a longer journey toward climate neutrality that will transform cities and unite them around a shared vision for a just climate transition.

The NetZeroCities project, which is financed by Horizon 2020, will provide overall support for the activities with 32 million euros in awards. In addition, NetZeroCities will give knowledge and technical assistance in the implementation of the projects, assisting them in securing the investment and money required to reproduce and scale solutions. According to Mariya Gabriel, European Commissioner for Innovation, Research, Culture, Education and Youth, their experience will serve as an example to all cities in the European Union and beyond. The Pilot Cities Program is just one of several building blocks put in place by the European Union Cities Mission. I encourage all cities to check out all future initiatives, engage with citizens and stakeholders now and prepare their strategy to become climate neutral.

The following cities were selected from the Pilot Cities Program.

It should be highlighted that two Fin cities were selected to be compared to Guimarães (Turku and Lathi) due to the similarities those cities have with it regarding demographic characteristics. It is also important to refer that Finland was ranked in the 1st place for the last three years in The Sustainable Development Report (2021, 2022, 2023). One may state that the reasons for Finland be ranked this way were related to the competencies ending poverty, ensuring inclusive and equitable quality education for the entire population or access to reliable and sustainable energy sources at affordable costs.[15]

4.3.1 Drammen (Norway)

The Paris agreement (2015) settled a plan to avoid the overcoming the average 1.5 C (Celsius) degrees. In the shorter term, emissions are expected to reduce by 45 % by 2030 and reach net zero by 2050 in longer term (UN, 2015)[16].

Norway is one of the 195 states which belongs to this agreement, despite Norway's comprehensive climate action plan was approved on January 8th, 2021, to achieve climate commitments under the Paris Agreement while also promoting green growth.

[15] https://plan.fi/wp-content/uploads/2021/05/progress_on_sdgs_in_finland.pdf accessed in 10 April 2024
[16] https://netzerocities.eu/drammens-pilot-city-activity-zero-emission-2030/ accessed in 10 April 2024

However, Norway's has been more ambitious than the own Paris Agreement, because it aims to be carbon neutral by 2030. (IEA, 2022)[17].

To achieve a more sustainable world it was created the 2030 agenda for sustainable development goals, envisaging "a world of universal respect for human rights and human dignity, the rule of law, justice, equality and non-discrimination".

Regarding the 2030 Agenda the goals 6, 7, 8, 9, 11, 12, 13, 14, 15, 16 and 17' s are more linked with sustainability to improve environment at a global level (UN, 2015)[18].

Drammen has emphasizing some of those goals. A good example of this is port of Drammen, which had taken some measures into practice, like the plan outlines the development of innovation and infrastructure, including strengthening intramodality and relocating freight transport to sea and railway. It also emphasizes sustainable cities and communities, with plans for city-friendly port operations, green belts, and noise reduction. Additionally, it aims to reduce emissions linked to port operations through electric cars and crane electrification.

The Port of Drammen is actively working to maintain a sustainable life under water and ensure safe water use around the port. They participate in the "Clean Drammensfjord" project, cover the seabed with clean gravel, and stop pushing snow over the quayside to prevent litter and heavy metals. They also collaborate with shipping companies and freight forwarders to implement environmentally friendly transport solutions.

The general focus of Draammen Municipality is based on innovation, sustainable buildings, and city development to produce sustainable municipal buildings and zero emission neighbourhoods with Futurebulilt Program support, whom is a Norwegian initiative to support sustainable cities through pilot projects. These same are set to reduce greenhouse gas emissions from transport, energy, and material consumption by 50% at least. Drammen was the first Norwegian municipality to join Futurebuilt in 2009 as a municipal partner, even before the capital of Norway, Oslo. Therefore, Drammen Municipality was an important start-up of this program (Sustainability and Environment.).[19]

[17] https://www.iea.org/reports/world-energy-outlook-2022 accessed on 10 April 2024
[18] https://sdgs.un.org/goals accessed in April 2014
[19] https://netzerocities.eu/drammens-pilot-city-activity-zero-emission-2030/ accessed on 10 April 2024

4.3.2 Guimarães

The Pilot cities program includes 53 cities that will implement innovative solutions in areas like as mobility, land use, and waste management.

The NetZeroCities initiative selected Guimarães as one of 25 Pilot Cities, making it the sole Portuguese municipality. The purpose is to test new kinds of decarbonization locally for two years, with 52 other European cities, using novel ways aimed at the urban climate transition.

The Portuguese city was chosen among 103 applications from 33 European Union (EU) member-states and is affiliated with Horizon 2020 (the EU framework program for research and innovation). Waste management, mobility and transportation, industrial processes, power and buildings, land use and thermal energy are among the sectors in which the selected cities will act. To facilitate information exchange, each city will be linked to other program participants.

Guimarães' pilot project "Distrito C: Compromisso de Carbono Zero" aims to integrate energy, mobility, waste, and land use through behavioural change, social innovation, culture, politics, green technologies, sustainable finance, and new business models.

"District C" would encourage substantial citizen participation in decarbonization using public transportation, energy efficiency, local renewable energy generation, including in historic buildings, and circular economy techniques, among other things Guimarães Is a Pilot City in European Decarbonization Project[20] In line with this the municipality began installing LED technology in street lighting in 2015. Moreover, the Guimarães City Council[21] has recently approved a 15-year contract with the company Amener, which will distribute the investment over time: €165,000 in 2024, €661,000 annually from 2025 to 2038, and €330,000 in 2039. Over this period, 14,600 streetlights—approximately 40% of the municipality's public lighting—will transition from sodium vapor lamps to LED technology, out of a total of 36,000 streetlights. The remaining 21,400 luminaires already use LED technology.

[20] https://peggada.com/en/guimaraes-is-a-pilot-city-in-european-decarbonization-project/ accessed on 15 April 2024

[21] https://jornaldeguimaraes.pt/noticias/camara-adjudica-contrato-para-dotar-concelho-de-iluminacao-led-a-100/ accessed on 8 June 2024

4.3.3 Lahti (Finland)

Lahti was the European Green Capital in 2021 (MacGregor-Fors et al., 2021).

The City of Lahti has addressed these challenges by establishing and promoting the Lake Vesijärvi initiative, in which university research groups, people, local businesses, and the city collaborate to enhance the lake's state.

The City of Lahti also set up the Lahti City consortium, which has invested €100 million in improving the city centre transportation system, including underground parking, additional bicycle lanes, and broader pedestrian areas.

The City of Lahti outperformed in most of the indicator areas, particularly Nature & Biodiversity, Noise, and Water. It got top rankings in Air Quality, Waste, Green Growth, Eco-innovation, and Governance[22].

It has done efforts to minimize the reliance on private transport. There are some surveys to measure that, whom almost all participants a replied that they used the new way of commuting most of the time during the pilot period (Villanen et al., 2023).

Sycla is a City Pilot in Lahti aiming to promote low and zero-emission commuting in workplaces. The project explores commuting barriers and enablers, proposes development measures, and evaluates their impacts through surveys, interviews, and workplace observations. The project aims to reduce road transport emissions. It also aims to provide local pilot organizations with information on staff commuting and encourage environmentally friendly transport. The results will contribute to the City of Lahti's climate objectives and sustainable urban mobility planning. The project is a collaborative effort between the City, LUT University, LAB University of Applied Sciences, and Päijät-Häme Wellbeing Services Country (Systemic Change towards Sustainable Commuting in Lahti | LAB.fi, 2023).

4.3.4 Leuven (Belgium)

The Leuven 2030 Urban Lab, was created on March 23rd, 2022 and aims to strengthen collaboration between KU Leuven, UCLL, Imec, city of Leuven, and Leuven 2030 on

[22] https://environment.ec.europa.eu/topics/urban-environment/european-green-capital-award/winning-cities/lahti-2021_en accessed on 15 April 2024

sustainability issues. The lab will use Leuven as a living laboratory, combining education, research, and social engagement to tackle urban sustainability challenges. On the next month Europe selects Leuven as pioneering climate city, thus one of the 100 cities chosen by the European Commission for the mission '100 Climate-Neutral and Smart Cities by 2030 '. European Commission commits itself to fund resources for those cities in the journey towards climate neutrality by 2030. On November 23rd, 2023, got its first climate contract, handing over to the European Commission. This contract includes 86 projects specially aiming for 80% CO_2 reduction, 10 guiding principles, and over 30 partners making concrete commitments, also including a financial section that provides insight into the financial logics and levers needed to finance these breakthrough projects and the Leuven transition. (Our Milestones, n.d.)[23].

4.3.5 Liberec (Chéquia)

CO2 emissions inventories from 2000, 2005, 2010, 2015, 2020, and 2030 indicate a downward trend, with diverse industries contributing. Liberec municipal buildings are being upgraded to enhance energy efficiency and minimize pollution. Incentive schemes for eco-driving and the creation of transportation hubs are intended to minimize transportation emissions. External engagement is required to oversee SECAP (Sustainable energy and climate strategy of the Statuory City of Liberec) implementation and significant energy projects. Funding is critical for the effective implementation of energy efficiency initiatives in the city, and there are still a several challenges for Liberec to overcome, especially in energy domain (Eichhammer et al., 2018[24]), due the small expansion of renewable sources and a slowly development of transport electrification (Prieto, n.d.)[25]. A lack of renewable resources remains, and the incentives are not enough yet.

[23] En.leuven2030.Be. https://en.leuven2030.be/about-leuven-2030/our-milestones accessed on 20 April 2024

[24] https://www.isi.fraunhofer.de/content/dam/isi/dokumente/ccx/2015/Building-policies_Brochure_Final_November-2012.pdf accessed on 2 April 2024

[25] https://netzerocities.eu/2023/12/20/european-cities-test-innovative-pathways-to-climate-neutrality-in-the-pilot-cities-programme/ accessed on 20 April 2024

Czechia's government «plans to phase-out coal, focusing on renewable and nuclear energy and maximizing energy efficiency and savings», said the Czech prime-minister Petr Fialla (2022) during the COP27 climate conference in Egypt.

According with the 2024 new legislation in the Czech Republic, it was approved an amendment of the investment incentives act. This law eliminates the requirement to obtain of the government for every investment incentive. It could be easier to speed up the process of energy savings and transformation. Investment incentives can be used to support the production of technologies and equipment that contribute to energy savings and transformation under favourable conditions. Newly supported products include heat pumps, photovoltaic systems, solar thermal systems, nuclear reactors, steam generators, water turbines, wind turbines, electrolysers for hydrogen production, meters, battery storage, insulation materials, charging stations for electric vehicles, biomass and electricity hot water boilers, power chips, traction batteries, and electric motors (Czech Republic Approves Amendment of the Investment Incentives Act, 2024[26]).

Consequently, Statutory City of Liberec may adjust its measures through the new legislation.

4.3.6 Turku (Finland)

Turku City Group aims to attain carbon neutrality by developing carbon sinks, producing renewable energy, and raising knowledge about climate change threats. The city intends to boost sustainable modes of transportation to more than 66% by 2030 and cut greenhouse gas emissions from street and road traffic by 50% by 2029. Turku is also working to address climate change issues relating to rivers, ecosystems, and species shifts. The city is aggressively working on energy reform, bringing together individuals, companies, and communities to cut greenhouse gas emissions. Various activities and

[26] *Czech Republic approves amendment of the Investment Incentives Act*. (2024). Ey.com. https://www.ey.com/en_gl/tax-alerts/czech-republic-approves-amendment-of-the-investment-incentives-a accessed on 20 April 2024

processes are being implemented to mitigate climate change and properly track success (Turku Climate Plan 2029 in Turku City Council, 2018)[27]

An approach was made on University of Turku to create climate-friendly personas living in Turku and then spread awareness of climate-friendly lifestyles amongst citizens. This research focuses on 1.5-degree lifestyles and lifestyle changes to reduce emissions, emphasizing the role of consumers in mitigating climate change (Katajamäki, 2021).

4.3.7 Limassol (Cyprus)

The Cyprus Public Works Department (PWD) conducted the ITS national master plan from 2007 to 2009. The strategy contained specific initiatives and mechanisms such as advanced traffic management, traveler information services, temporary ITS systems for construction zones, priority to specific vehicles at signaled junctions, weigh-in-motion systems, parking availability systems, and public transport ticketing systems are being implemented to improve traffic flow and efficiency in construction zones. Since the national ITS master plan, Cyprus has deployed the following systems, mostly in Nicosia but also in Limassol. (Bizakis & Giannopoulos, 2020).

The Municipality in Limassol aims to enhance waste collection services and traffic flow in the residential area, reducing traffic hazards, congestion, energy costs, and air contaminants discharge, thereby improving mobility and reducing energy consumption. Municipal interventions' impact evaluation involves using GPS data, geospatial data, daily traffic, internal data, and official social media. Expert-based FCMs are built using these data sets, with citizen participation encouraged through social media and workshops. Fuzzy cognitive maps can be used to simulate various scenarios, allowing evaluation of waste collection vehicle routes, both permanent and temporary, in case of road works or accidents (Pereira et al., 2018).

27
Turku Climate Plan 2029
Turku.fi
https://www.turku.fi › default › files › atoms › files
accessed on 2 September 2024

The goals are running according with the average citizens, they desire more public green parks for social interaction, bicycle lanes, pedestrian zones, infrastructure supporting active travel and public green spaces and then improve the well-being (Psara, 2021).

4.3.8 Umeå (Sweden)

Umeå collaborates with several European and northern Swedish cities to achieve the EU's goal of 100 climate-neutral and smart cities by 2030.

The project “The North Star” is based on the continuing work on the Umeå climate roadmap, where roughly 50 players from all around society collaborate to achieve the aim of a climate neutral Umeå. Despite the commitment, the climate transition is taking too long, and risks being hampered by a variety of societal hurdles, which the project will investigate and mitigate. Organizational practices dictate budgets, project models, and employee knowledge, addressing specific issues but creating conflict and hindering innovation in holistic areas like climate change. The focus is on reducing climate emissions through residents' and organizational behaviours, activities that various actors undertake without the municipality's mandate to influence. Organizations can reduce climate emissions by streamlining processes, but lack a comprehensive overview of the system transition, potentially causing negative impacts on other parts of the system. To become climate neutral, it’s necessary to deal with these obstacles and then work with better systems of innovation. The project utilizes RISE's (2023) expertise in system transformation, sustainable leadership, and transformation management to enhance actors' capacity and design and test prototypes for system innovation. The project aims to pilot-test system innovations, identifying barriers and obstacles, and transforming them into opportunities. Through workshops and prototyping, participants will collaborate with creative actors to find innovative solutions. The lessons learned will be applied to develop governance, collaborations, and practices, enabling system transition (The North Star | RISE, 2023).

The following table resumes the Pilot activity in some cities of EU according to Prieto, (2021).

***Table 7**: Pilot activity in some cities of EU, 2021*

Pilot city activity	Emphasis	Proposals	Targets
Drammen	Zero emission 2030	To implement an evidence-based strategy to tackling world urban concerns such as green (solar) energy, circular economy, mobility, and citizen health and well-being.	• A boost in green energy capacity through solar energy; re-establishing circularity for natural resources derived from construction, renovation and deposits; • Sharing, reuse, and repair amongst citizens reducing the household's food waste; • Reduce traffic emissions through shared mobility as bike-sharing, micro-mobility and car-sharing; • Regenerate the Drammen River and its banks for improve the health and welfare co-benefits.
Guimarães	District C - A zero-carbon commitment	Implement pilot activities that will serve as a test bed for a variety of initiatives aimed at achieving a zero-carbon district, with a particular emphasis on public involvement and developing a feeling of community.	• Electricity comsumption for buildings, facilities and infrastructure; • Raise awareness among citizens about improving energy efficiency in their homes; • Multi-family housing: condominium regulations; • Improve investiment capacity of eletric energy; • Encourage a new cultural awareness about circular economy and waste management; • Increases awareness of ways to connect with nature, through sustainable practices such as urban community gardens and green spaces.
Lahti	Systemic change towards sustainable commuting in Lahti	To develop solutions for the transition to sustainably commuting through a collaborative approach with local organizations and their employees.	• Aims to become carbon-neutral by 2025, focusing on mobility and transport sectors; • Icreases the alternative fuels to reduce mobility emissions; • Proposes co-creation process for sustainable commuting with local organizations and employees; • Improve cultural, institutional, and structural aspects; • Encourage the citizens to waive the car replacing for more sustaibanble options as the bike and public transport.
Leuven	Implementation of the city's energy strategy set to net-zero effort	To decarbonize the heating system, when applicable, in conjunction with retrofitting and deploying renewable energy.	• Coordinated climate planning across departments; • Implemented Civic Contracting for distributed leadership and agency; • Mixed financing generated and distributed through a municipal investment entity; • Place-based engagment and execution by apartment building owners and inhabitants; • Learning and reasoning for better decision-making.
Liberec	The Initiation of Sustainable Energy Community for the City of Liberec: Statutory City of Liberec	Guidelines for developing an energy community plan, as well as the development of a communication tool to increase awareness and foster collaboration on low-emission transportation and community energy issues.	• Expedite the expansion of renewable energy sources; • Speed up the development of transport electrification; • Imporve the stakeholders in the city to bring up better communication and cooperation; • Creates a new governance model for improving social innovation, thus also improving behavioural change; • Implementation of new legislation (2024) in the Czech Republic to overcome the current problems about transportation and efficient energy.
Limassol	LC^3 - Limassol City Cooling Challenge	Demonstrate scalable and transferable strategies to minimize energy use for cooling in a southern coastal city.	• Reduces cooling energy and generates renewable electricity; • Engajes stakeholders in participatory co-design workshops; • Systemic approach as covers on-the-ground, including: -capacity building; -smart green financing tools; -emissions monitoring; -participatory democracy paradigm.
Turku	1.5-Degree City	To facilitate systemic change towards sustainable lives and enterprises via an online monitoring platform, local company climate networks, and nudging-based communication campaigns.	• An online portal will track climate activity by city groups, businesses, and people, enabling systematic and cross-sectoral action. Carbon footprint and handprint estimations are being created and evaluated; • The City of Turku is expanding its Climate Team network by undertaking approximately 100 climate actions with over 120 partners, focusing on the largest enterprises and offering knowledge-based support in climate work; • Sustainable 1.5 degree living necessitates completing lifestyles, public envolvment and motivanting climate motivation efforts. Free-time mobility is being tested with residents to ensure a more sustainable future.
Umeå	The North Star	To enable a new method of working with key stakeholders in the city to overcome organizational lock-ups and support behavioural change in important emission areas such as mobility and transportation, energy and built environment, and consumption and circular economy.	• Reduces the risk of sub-optimization to prevent the transition to CO2 emission reductions from being uncoordinated and several counterproductive solutions; • Enhence public servants' knowledge, abilitiesand attitudes toward systemetic reforms, as well as improving stakeholder organization to attain climate neutrality.

Source: Adapted from Prieto (2021)

Conclusion of the literature review

The concept of smart city was developed by means of an extensive literature review.

Smart cities have been a topic of significant interest and investment in recent years, with numerous initiatives and projects underway in various parts of the world. They integrate advanced technologies to tackle modern challenges like population growth and globalization.

Originating in the 1970s, with Los Angeles as a pioneer, the concept of smart city gained momentum in the 2000s, driven by technological advances and academic interest. The concept was developed in three waves. The first wave was developed between the 80´s and 90´s and was characterized by being rather dismantled. The second wave was considered a corporativist one and was developed between the 2000s and mid 2010s. The third wave is now under development, and it has more humanized features like the inclusion of the challenges related to sustainability, climate change and quality of life.

Beyond technology, smart cities focus on sustainable growth, quality of life, and resource management. They use ICT and IoT to enhance urban systems like transportation and waste management while addressing climate change and other challenges.

Early definitions of smart cities often focused heavily on technology (e.g., Hall et al., 2000; Giffinger & Kramar, 2007; Dr. S. Musa, 2016). Some researchers emphasize sustainability in smart cities (e.g., Lazaroiu & Roscia, 2012; Bakici, Almirall, & Wareham, 2013; Woods, 2020); other definitions consider social aspects (e.g., Yun & Lee, 2019); some researchers focus on economic aspects (e.g., Attour & Rallet, 2014; Kourtit, Nijkamp, & Steenbruggen, 2017). Governance issues have also been considered (e.g., Shea, 2020) and other authors propose an integrated perspective of the dimensions (e.g., Batty, 2013; ITU-T Recommendation Y.4900; Kumar et al., 2018).

In summary, the concept of a smart city is dynamic and multifaceted, involving the intelligent interaction of systems and people to create sustainable, efficient, and responsive urban environments. This approach aims to improve the quality of life, economic value, and environmental sustainability for all citizens.

Finally, we provide a study of the most recognized models on smart cities and some examples of smart cities according to the IDM smart cities index, because the most recognized examples are included in this index (e.g. Oslo, Copenhagen, London). Yet, considering that Guimarães is more comparable with other "smart" projects, some other relevant smart cities` projects were provided (e.g. Lahti in Finland; Leuven in Belgium; Liberec in Chéquia). Being Guimarães a town with some particularities in terms of dimension (small) and sociodemographic characteristics that demand a different approach more connected with what the literature names as Pilot Cities, some twin cities are also mentioned.

The following part is dedicated to the empirical study, the application of the conceptual part to the case of Guimarães.

PART II

Empirical Research

In this part we describe the activities developed in the internship and mention the activities that Guimarães is developing and intends to develop to become a smart city by comparing it with Pilot Studies on smaller smart cities among European Union and Europe.

Next, we gathered information to characterize the dimensions that Guimarães uses as a guide to become a more intelligent city.

Finally, a methodology is proposed and justified to provide the answer for the research question.

A conclusion is drawn in the end.

5. Brief description of the context and the purposes of the internship

In this topic we describe the activities developed in the internship as well as the procedures involved in the designing of the internship plan.

This internship was developed in Guimarães city council in the department of Territorial Development under the supervision of Pedro Sousa, architect and director of the aforementioned department and with the help of Rita Salgado a landscape architect. The internship was held between the 2nd November 2023 and the 30th March 2024 according to the internship protocol signed between the Faculty of Arts and Humanities of University of Porto and the Guimarães city council.

A detailed program was designed by the candidate, the faculty supervisor, Professor José Alberto Rio Fernandes, PhD, and the Guimarães` city council supervisor, Architect Pedro Sousa. For this purpose, a meeting with architect Pedro Sousa occurred in his office in the city council in early September 2023. The program consisted of:

1- the definition of the smart city concept
2- research on the smart city models
3- collecting data about the development plan of Guimarães towards an intelligent city (what exists and what is planned to exist…)
4- methodology (interviews to internal stakeholders and questionnaires to the public)
5- data analysis and concluding remarks

Steps 1 and 2 are provided in the literature review, steps 3, 4 and 5 are detailed above. Steps 3 and 4 were developed with the support of architect Rita Salgado namely:

- selecting the internal stakeholders (people working in the city council in strict relation with urban planning) to be interviewed and
- providing very relevant insights regarding the interview guide and the questionnaire to those who use the city (residents, workers and students).

6. Comparison between Guimarães and other smart cities with identical socio-demographic features

This subtopic intends to compare Guimarães to other smart cities with identical socio-demographic features. Some belong to the Pilot studies among European Union (EU) and others are part of other European countries outside the EU.

6.1 Guimarães and Liberec

"Liberec and Guimarães, are setting up energy communities to test out a range of solutions in specific areas, from transport and energy consumption in buildings to improved waste management"[28] (Prieto, 2024).

The main difference between Liberec and Guimarães is the fact that Liberec's renewable resources are not enough to adjust to its needs while Guimarães has a lack of citizen's culture engagement and investment. Liberec has also a problem with citizen's participation, but that doesn't come top.

6.2 Guimarães and Drammen

Drammen and Guimarães are too different in terms of its approaches.

Although Guimarães is also looking for carbon neutrality, it will just work in specific districts/ areas at middle-term. Guimarães has also a focus on waste management meanwhile Drammen intends to boost its green energy through solar energy and, about waste management Drammen municipality is more developed than Guimarães, it will also work on reducing household's food waste and will take advantage of its larger river (Drammenselva), compared with the Ave River in Guimarães, to regenerate its banks.

Thus, then getting the carbon neutrality until 2030.

[28] https://netzerocities.eu/guimaraes-pilot-city-activity-district-c-a-zero-carbon-commitment/ accessed in 4 May 2024

6.3 Guimarães and Lathi

Lathi has sustained similar problems with Guimarães like the citizen's involvement. However there´s worst problems in Lathi due according to the past projects and surveys, there's a dependence of private vehicles due the lack of public transport, cycling and pedestrian routes, meanwhile Guimarães is a quite better.

6.4 Guimarães and Leuven

Leuven is more developed in terms of communication of its stakeholders, partnerships. Their net-zero-efforts are linked with decarbonizing heating, when appropriate, in conjunction with retrofitting and renewable energy solutions.
Meanwhile Guimarães has a fewer investment capacity in these aspects if we compared with the Belgian city, Leuven.

6.5 Guimarães and Limassol

Guimarães and Limassol have a few differences when we talk about energy solutions because Guimarães intends to improve energy efficiency throw energy and waste management, meanwhile Limassol is more focusing to reduce energy consumption for cooling in its Cypriot's southern coastal city. It's reasonable due Limassol is next to sea and Guimarães does not.

6.6 Guimarães and Turku

Guimarães and Turku intends to overcome the challenges of carbon neutrality, but Turku is more developed in terms of several partnership communications and the University of Turku has developed several projects and surveys to encourage the citizen´s engagement.

6.7 Guimarães and Umeå

Guimarães and Umeå towards to carbon neutrality and Umeå intends this until 2030. Although Umeå is more advanced in the mentioned aspects, the approaches are a quite like Guimarães, throwing up mobility and transport, energy and built environment, consumption and circular economy, which includes the focus of the pilot test activity of "The North Star" initiative.

After comparing Guimarães with other smart cities with identical/comparable socio-demographic features (some described in the Pilot studies among European Union (EU) and others that are part of European countries outside the EU) we describe the methodology used in this study to analyse the data.

7. Methodology

Here we justify the methodology selected to answer to the research question and to reach the proposed objectives. We began by reviewing literature on methodology to choose the methods and techniques that we consider adequate to answer the research question and the underlying objectives.

7.1 Purpose of methodology

According to Crossley (2021) methodology describes the how and why of the research design.

According to Cargill & Connor (2013) students are, traditionally, taught that the methods section provides the information needed for another competent scientist to repeat the work. But the same authors point out another way to think about the goal of the methods section. They consider that it establishes credibility for the results and should therefore provide enough information about how the work was done for readers to evaluate the results.

The purpose of methodology is to allow how to show our understanding, the study becomes more replicable, and the methodology also allows to identify and discuss limitations (Crossley, 2021), and then explaining the reasoning behind of the approach to our research. It's also important support methods, methods of analysis and other key points for our work (Paperpile, 2022).

The major methodological choice regards analysis techniques. This means how to analyse data after collected it. This choice must be in line with the research objectives and, of course, with the research question. According to Yin (2014) there are different research methods for each relevant situation:

***Table 8**: Research methods according to the form of research questions*

Method	Form of research question	Requires control of behavioural events?	Focuses on contemporary events
Experiments	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival Analysis	Who, what, where, how many, how much?	No	Yes/no
History	How, why?	No	No
Case Study	How why?	No	Yes

Source: Adapted from Yin (2014)

Although the substance of the questions can vary, Yin (2014) showed us that their form (in terms of 'who', 'what', 'where', 'how' and 'why') gives us clues about the research strategy to be used and concluded that the case study strategy is more appropriate for 'how' and 'why' type questions, so the researcher's initial task should be to clarify the nature of the questions being studied.

The type of research design is also related to the data type, the approach and the analysis. Usually the type of the research design is divided in two main categories: qualitative and quantitative research. A brief description of each follows.

7.2 Types of research design

Generally, research can be developed qualitatively or quantitatively.

Qualitative research is considered more subjective because the meaning and context of phenomena are understood through in-depth exploration and interpretation (Dr. Munther Mohammad Zyoud et al. 2024). It can be used to understand how individuals perceive and give meaning to their social reality. According to Denzin & Lincoln (2011), qualitative researchers study phenomena in their natural settings in terms of meanings people bring to them.

Qualitative research encompasses several forms of the investigation. They all share this characteristic: the data used do not accommodate readily to quantification, specification, objectification, or classification. Because of that, common statistical procedures cannot be used for data display or analysis. Typical of such data might be

reports of participant observation or the texts of in-depth and relatively unstructured interviews. (Mauch & Birch, 1998)

For qualitative studies, common analysis methods include content analysis, thematic analysis and discourse analysis (Crossley, 2021).

Qualitative analysis is a valuable research method that provides in-depth insights into complex phenomena, but it has certain limitations like:

- subjectivity (bias related to the researcher's own interpretation);
- limited generalization (limited scope due to the common use of small, non-random samples that are specific to a particular context or group), and context specific because the results are often deeply tied to the specific context in which the research was conducted;
- difficult to quantify a phenomena and replicate studies (reduces reliability);
- generates a lot of unstructured data (e.g., interview transcripts, observation notes), that can be overwhelming and challenging to organize and analyse effectively;
- dependence of the researcher´s skills

It can be of great use particularly when used in conjunction with quantitative methods to provide a more comprehensive understanding of the research problem.

Quantitative research is considered more objective for it involves collecting and analysing numerical data to describe, predict or control variables of interest (https://www.simplypsychology.org/qualitative-quantitative.html#Examples). The main purpose is to test causal relationships between variables, predict and generalize results to population. One of the main benefits of using quantitative methods is the capacity to extrapolate results to larger populations (Zyoud et al. 2024). Researchers can assess correlations between variables and test theoretical claims by using quantitative methods to enable rigorous statistical analysis and hypothesis testing (Hair et al., 2010). Nevertheless, the qualitative dimensions of the reality under analysis might be difficult to capture using only qualitative approaches. According to Denzin & Lincoln (2011) quantitative data may miss the richness and depth of human experiences, emotions, and behaviours to fully comprehend some aspects of the phenomena.

A summary of the main features of qualitative and quantitative research is provided below:

***Table 9**: Comparison between qualitative and quantitative analysis*

	Qualitative	Quantitative
Purpose	"Why" question Limited generalization	"How many/much" Aims to predict and generalize results to population.
Data type	Words, observation, symbols	Number/statistical conclusions
Sample	Smaller sample sizes	Larger sample sizes
Approach	Explore, observe and interpret Subjective	Measure, test Objective
Analysis	Non-statistical: grouping common data Content analysis, thematic analysis and discourse analysis	Statistical analysis and hypothesis testing
Examples	Focus groups and in-depth interviews	Online surveys and computer-assisted telephone interviewing (CATI)

Source: Own elaboration

To overcome the limitations of the single use of quantitative or qualitative research researchers can use mix methods to provide a more comprehensive understanding of the research problem.

Creswell (2021), Denzin & Lincoln (2011) identified and characterized these three types of methodology analysis. Creswell (2021) describe it as three distinct approaches that "designs to be different types of inquiry within these different approaches". Denzin & Lincoln (2011) called "strategies of inquiry".

The three authors reciprocally agree that it is an efficient way to compare these approaches with each other.

For Bernard (1996), quantitative analysis involves reducing people to numbers and qualitative analysis evolves reducing people to words.

Mixed methods means that you collect both quantitative and qualitative data and analyse both together to answer of some question (University of Northampton, 2018).

Mixed-method research also enables triangulation, which is the utilization of various sources of data to corroborate or disprove research conclusions. Using many data sources improves the validity and reliability of your results. Triangulation can also help reveal anomalies or contradictions in data, which can then be resolved through additional study.

Triangulation of methods is a research strategy used to enhance the validity and reliability of study findings by combining multiple research methods or data sources. It helps to cross-check and verify results, reducing the risk of bias and providing a more comprehensive understanding of the research problem.
By employing triangulation, researchers can strengthen their studies, making the conclusions more credible and generalizable. It is particularly useful in complex research areas where a single method might not capture all relevant aspects.

Triangulation was defined by Denzin (1970, 1989) as the combination of methodologies in the study of the same phenomenon.

Denzin (2017) proposes four types of triangulation:

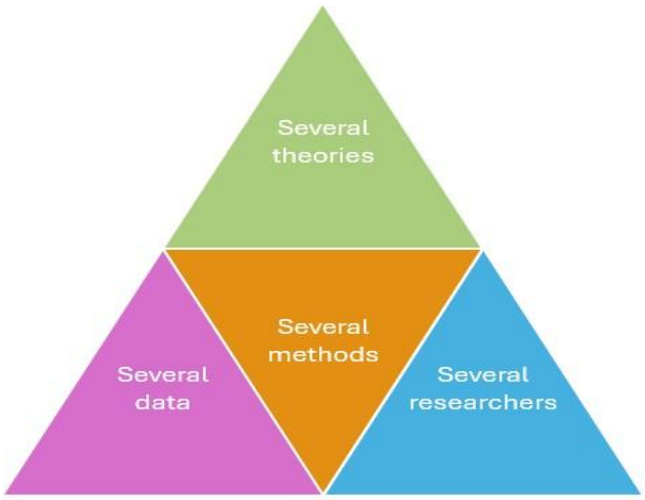
(1) data triangulation, which includes matters such as periods of time, space and people;
(2) investigator triangulation, which includes the use of several researchers in a study;
(3) theory triangulation, which encourages several theoretical schemes to enable interpretation of a phenomenon and
(4) methodological triangulation, which promotes the use of several data collection methods such as interviews and observations.

In 'methodological triangulation', multiple methods are used to study a particular research problem. There are subtypes: within-method triangulation - which involves

using the same method on different occasions - and between-method triangulation - which means using different methods in relation to the same object of study.

For Denzin (2012), the aim of triangulation is to design a plan of action that would overcome the differences between researchers arising from the use of just one methodology.

***Figure 2**: Methodological triangulation*



Source: Denzin (2012)

Triangulation has a long history in qualitative and social research as an implicit and explicit concept (Flick, 2018). Triangulation is not only about seriousness and validity, but also allows for a completer and more holistic picture of the phenomenon under study (Denzin, 2012). Other authors suggest 'triangulation' as a way of integrating different perspectives on the phenomenon under study (complementarity) (Kelle, 2005; Kelle and Erzberger, 2005; Flick, 2005), as a way of discovering paradoxes and contradictions (Kelle and Erzberger, 2005), or as a form of development, in the sense of using methods sequentially so that the use of the initial method informs the use of the second method (Greene et al., 1989).

Taking these methodological issues into account we present the selected research question and the general and specific objectives in the next topic.

7.3 Research question, general and specific objectives

It was already mentioned in the Introduction, yet we consider that it should be highlighted here that we define the following research question:

Research Question

How is Guimarães responding to the challenge of becoming a smart city?

This research question has some objectives at its basis. A general objective and three specific objectives.

General and specific objectives

The general objective of this dissertation/report is to contribute to knowledge of the city and, if possible, to intervene with a view to improving Guimarães as a "smart city", considering what the city has done in recent years and highlighting the year 2023.

Therefore, the following can be outlined as specific objectives:

1) To synthesize the encounter between the theoretical dimension - what a "smart city" is (should be) and what Guimarães has done, is doing and intends to do to offer smart city solutions to its citizens.

2) To compare Guimarães' path with that of other cities and evaluate the road travelled.

3) To evaluate the congruence between what the decision makers are doing regarding the development of Guimarães as a smart city and the perspective of the people who live, work or study there, therefore a perspective from inside Guimarães.

To answer the research question guided by the general and specific objectives we propose to develop research using triangulation between methods as defined by Denzin (1970, 1989). In a first step qualitative analysis is used my means of in-depth interviews - semi-structured interviews designed under an interview guide (Appendix 2). In this step

internal stakeholders – people working in the city council that have intervention in the decision process, namely with the urban planning department, are questioned. In a second step, quantitative analysis is developed using a survey (by means of a questionnaire) developed to be answered by the people who live or work or study in Guimarães with the purpose of concluding/understanding if the activities performed by the interviewees are being well accepted by the people who interact with the city of Guimarães. This approach intends to provide a perspective from inside the city.

In the next topic we analyse the data provided by the interviews and the survey by means of a questionnaire.

8. Guimarães, as a smart city: a perspective from inside

In line with the proposed research question and taking its form into account (Yin, 2014), we first decided to carry out a qualitative analysis using semi-structured interviews. This analysis allows us to better explore the thoughts and beliefs of individuals, as well as giving us important insights for the subsequent quantitative analysis.

Two interviews were carried out with individuals who work at Guimarães City Hall and are involved in urban planning decisions. For reasons of their schedules, the interviews were scheduled by the architect Rita Salgado. For that purpose, an interview script was designed (Appendix 2) with her guidance. After being validated by Professor José Alberto Rio Fernandes, the interviews were conducted by email due to constraints linked to the professional activities of each participant.

According to Dahlin (2021) email interviewing can be fruitfully combined with explorative interviewing, offering the researcher a way to strategically work with the extended time frame that asynchronous interviewing brings with it.

There are many advantages of email interviewing.

Recent research mentions that researchers have illustrated how email interviewing can capture the complexity of social practice on the internet (James, 2016) and how the responses from participants can result in well-written, rich and informative reports (Bowker & Tuffin, 2004; Gibson, 2010; James, 2007). Other advantages are related to the fact that email interviews are already transcribed and asynchronous interviewing offers the participant an opportunity to reflect and, therefore, provide more reflected answers (Pell et al., 2020). Also the fact that the participants might be in different geographies and time zones is facilitated with email interviews (Opdenakker, 2006). We can conclude that email interviews allow a more flexible choice of participants (Valdez & Gubrium, 2020).

About disadvantages literature refers that researchers mentioned that email interviews can be more time consuming (Fritz & Vandermause, 2017), and body language of the respondents cannot be observed (Burns, 2010), therefore this cannot be a suitable option in studies where visual cues are significant (Santana et al., 2021).

The answers were collected in May 2024.

In what regards analysis techniques, we could decide between discourse and content analysis. Considered the differences between both techniques, detailed above, we decided to use content analysis due to being more realistic, objective, analytical, deductive and because it uses a quantitative focus that permits a simpler interpretation.

***Table 10**: Comparison between qualitative and quantitative analysis*

	Discourse Analysis	Content Analysis
Ontology	Constructionist - assumes that reality is socially constructed	Realist - assumes that an independent reality exists
Epistemology	Meaning is fluid and constructs reality in ways that can be posited through the use of interpretive methods	Meaning is fixed and reflects reality in ways that can be ascertained through the use of scientific methods
Data Source	Textual meaning, usually in relation to other texts, as well as practices of production, dissemination, and consumption	Textual content in comparison to other texts, example over time
Method	Qualitative (althought can involve counting)	Quantitative
Categories	Exploration of how participants actively construct categories	Analytical categories taken for granted and data allocated to them
Inductive/Deductive	Inductive	Deductive
Subjectivity/Objectivity	Subjective	Objective
Role of context	Can only understand texts in discursive context.	Does not necessarily link text to context
Reliability	Formal measures of reliability are not a factor although coding is still justified according to academic norms; differences in interpretation are not a problem and may, in fact, be a source of data	Formal measures of intercoder reliability are crucial for measurement purposes; differences in interpretation are problematic and risk nullifying any results
Validity	Validity in the form of "performativity" i.e., demonstrating a plausible case that patterns in the meaning of texts are constitutive of reality in some way.	Validity is in the form of accuracy and precision i.e., demonstrating that patterns in the content of texts are accurately measured and reflect reality
Reflexivity	Necessarily high - author is part of the process whereby meaning is constructed.	Not necessarily high - author simply reports on objective findings.

Source: Hardy et al. (2004)

According to Valle & Ferreira (2024) content analysis corresponds to a set of techniques through which a group of data can be analysed. It is widely used in qualitative research, especially in investigations in the field of education, as it is a very effective way of understanding the content, not always manifest in a discourse (whether it be a text, a gesture, or the utterance of a phrase, that is, any form of communication).

Bardin (2018) defines content analysis as a systematic, objective, and quantitative method for analysing communication content. The approach focuses on identifying and categorizing patterns and meanings within the data. This author emphasizes the following key aspects:

Systematic Process: The analysis must adhere to a clear, replicable procedure to ensure consistency and reliability.
Objectivity: Efforts should be made to minimize personal bias by using well-defined categories and coding schemes.
Quantitative and Qualitative: While quantitative analysis focuses on the frequency of elements, qualitative analysis delves into the deeper context and meanings.
Categorization: Content should be organized into categories based on themes or concepts, allowing for a structured and insightful analysis.
Inference: The aim is to draw conclusions about the underlying messages and broader implications within the content.

According to Valle & Ferreira (2024) content analysis corresponds to a set of techniques through which a group of data can be analysed. It is widely used in qualitative research, especially in investigations in the field of education, as it is a very effective way of understanding the content, not always manifest in a discourse (whether it be a text, a gesture, or the utterance of a phrase, that is, any form of communication).

The aim of the interviews was to explore the potential opened by the Smart City concept: discussion of the concept - what is a smart city and what should it be? and evaluation of the path taken towards making Guimarães a smart city. In other words, it is linked to specific objectives 1 and 2, i.e,
1) To synthesize the encounter between the theoretical dimension - what a "smart city" is (should be) and what Guimarães has done, is doing and intends to do to offer smart city solutions to its citizens.
2) To compare Guimarães' path with that of other cities and evaluate the road traveled.

In line with this we analysed each interview and summarized the most cited words by each interviewee in word clouds. We must highlight that the interviews were developed in Portuguese language therefore the word clouds are in the same language.
Before analysing the interviews, we present a summary table with the main characteristics of the interviews.

Table 11: Characterization of the interviewees

Interview	Gender	Age	Scholarity	Experience (years)
1	F	44	Bachelor in architecture	21
2	F	26	Bachelor in Geography (geographic information systems)	22

Source: Own elaboration

The most cited words by the 1st interviewee are (from the most to the least mentioned): Guimarães, development, sustainable, governance, territory, model, mobility, public, quality, life, transport, heritage, citizens, challenges, city, university, projects, academia, innovation, companies, carbon, circular, economy, innovation, education, solutions and other word with less expression.

Figure 3: *Word cloud (1st interview)*

Source: Own elaboration (https://www.wordclouds.com/)

The same analysis was pursued to the 2nd interview. The most cited words are (from the most to the least mentioned): Guimarães, management, national, risks, prevention, neutrality, carbon, innovation, territory, development, Portugal, research, solutions, multidisciplinary, planning and other word with less expression.

***Figure 4**: Word cloud (2nd interview)*

Source: Own elaboration (https://www.wordclouds.com/)

Finally, we decided to join both discourses and find the most cited words. As we can see above the most cited words are (from the most to the least mentioned): Guimarães, national, management, carbon neutrality, prevention, innovation, territory, risks, integration, intelligent, multidisciplinary, cooperation, excellence, services, decarbonization, international, team, public, planning wellbeing, city, research and other word with less expression.

Figure 5: *Word cloud (both interviews)*

Source: Own elaboration (https://www.wordclouds.com/)

Both interviewees are female with ages between 44 and 46 years old and are bachelors (the 1st has a background in the field of architecture and the 2nd is a geographer specialized in geographic information systems). They both work in the city council for more than 20 years

After representing the most cited words a more profound analysis is needed to respond to the 1st and 2nd specific objectives:

Specific objective 1) To synthesize the encounter between the theoretical dimension - what a "smart city" is (should be) and what Guimarães has done, is doing and intends to do to offer smart city solutions to its citizens.

In this context the 1st interviewee refers that “a smart city should aim to create and develop strategies and apply them in concrete actions, based on new paradigms of sustainable urban development that in turn contribute to increasing the quality of life of citizens”.

When asked about the purpose of an intelligent city, the 2nd interviewee refers to the constant search “for innovative sustainable solutions (in areas such as land management, water management, mobility and transport, buildings, energy efficiency, waste, tourism, civil protection), with the aim of responding to the challenges facing cities in order to speed up services and provide quality of life and well-being for their citizens”.

From both statements we may conclude that developing and applying strategies based in new paradigms of sustainable development, using sustainable solutions in areas such as land management, water management, mobility and transport, buildings, energy efficiency, waste, tourism, civil protection aiming to provide a better quality of life and wellbeing for citizens. These approaches are much in line with the third wave of the historical evolution mentioned in the literature review – driven by needs and desires of citizens and communities and therefore focused on people and far from the interests of the large technology companies as it was in the second wave (2000s to 2010s)

When asked about what Guimarães has done, is doing and intends to do to offer smart city solutions to its citizens, the 1st interviewee refers to the fact that “Guimarães is now recognised as a model of inspiration for other cities for the way it has been able to implement a participatory, multidisciplinary and integrative governance model. The Governance Ecosystem - Guimarães 2030 has been the target of distinctions that validate a model that can involve the public and private sectors, academia and the citizen, the latter as the driving force behind all this transformation”. And she continues

mentioning that “this Governance Ecosystem is a process that has been underway since 2014 and which, for three consecutive years, has enabled Guimarães to be considered the most sustainable municipality in the country - Eco XXI Municipality”.

The 2nd interviewee mentions that “Guimarães is committed to being a more intelligent, innovative and citizen-friendly territory, with the following main initiatives:

- Guimarães has an integrated operations centre, with technicians specialised in data collection and analysis, enabling better planning and intelligent management of the territory.
- As part of the Space4Cities consortium, Guimarães obtained funding from the HORIZON-EUSPA-2022-SPACE programme, which aims to develop and integrate intelligent systems using satellites to manage public spaces, reaffirming the aim of boosting the sector and establishing the region as a centre of excellence in aerospace research and production.
- Guimarães is one of 53 selected for the NetZeroCities Pilot Cities Programme, an ‘unprecedented climate action’ whose mission is to test new and innovative forms of decarbonisation locally for two years (https://netzerocities.eu/pilot-cities-cohort-1-2022/).
- Guimarães is part of the Smart Portugal programme.
- Guimarães has been selected for the integrated edition of the Smart Portugal space.

Regarding the priorities that Guimarães should have to become e more intelligent city, both interviewees mentioned public transportation (we may say that the new Public Road Passenger Transport concession, with the largest fleet of electric vehicles in the country) the promotion of soft mobility, carbonic neutrality and risks prevention.

The 1st interviewee mentions “the strengthening of the electric vehicle charging network, municipal energy efficiency, the promotion of a circular economy in all key sectors and the commitment to protecting and enhancing the natural heritage are priorities that Guimarães sees as necessary to reduce carbon emissions.” She adds that education is “the root of all these transformations” therefore there is a strict connection with schools by providing them with the necessary technology means towards digitalization and to higher education like University of Minho with a campus in Guimarães with whom the municipality has several projects.

According to the statements and the desk research developed by the author, we must agree that Guimarães is deeply engaged in developing smart solutions to improve its citizens quality of life namely in terms of carbon neutrality, smart mobility, waste and water management and providing rich experiences to the tourists. This engagement is achieved by a multidisciplinary team formed by the municipality, the academia (namely University of Minho and University of Trás-os-Montes and Alto Douro) and other relevant stakeholders like research centres in conjunction with the planning and territory use department of the city council.

Specific objective 2) To compare Guimarães' path with that of other cities and evaluate the road travelled.

When asked about how to evaluate the growth already achieved by Guimarães as a smart city when compared to other cities of a similar size and characteristics, namely based on the achievements of 2023 interviewee 1 emphasized the Governance Ecosystem - Guimarães 2030 and the project named Cities Mission "as an opportunity to consolidate the practices that will make Guimarães a climate-neutral city and, at the same time, a model city throughout Europe". She added that, nevertheless, there are several challenges for which the most appropriate, innovative, participatory and mobilizing solutions need to be found and mentions that "Guimarães is implementing a participatory, multidisciplinary and integrative governance model, which includes all members of the municipal executive and is supported by the External Monitoring Committee, made up of prominent figures linked to sustainable development, including Mohan Munasinghe, professor emeritus, who recently won the Blue Planet Prize in 2021. This is a structure that includes academia (University of Minho, University of Trás-os-Montes and Alto Douro, the Operational Unit for Electronic Governance of the United Nations University and the Polytechnic Institute of Cávado and Ave), and which also has the Landscape Laboratory, an environmental research and education centre, as technical and scientific support for various projects aimed at the sustainable development of the territory, together with the collaboration of municipal companies and various technicians from the Municipality, namely from the Planning and Spatial

Planning Division. Interviewee 2 stated that Guimarães is in the forefront of the road to become a more intelligent city.

Considering the measures recently taken about the separation of organic and common trash, and those that are expected in a near future in terms of energy efficiency (achieving 100% public lighting using LED luminaires), the interviewees were asked how they expect Guimarães to grow to become an increasingly intelligent city? What is missing? What opportunities are there for improvement?
Interviewee 1 mentioned that the road to decarbonization has led to:
-the construction of the Gymnastics Academy, a building close to zero carbon,
- the Urban Ecovias or Riverside Ecovias projects on the Ave, Selho and Vizela rivers,
- the projects that encourage the transition to a circular economy - RRRCICLO,
- Circular Economy in Guimarães
- the new Public Road Passenger Transport concession, with the largest fleet of electric vehicles in the country.
Interviewee 2 refers the necessity to invest on space technologies to combat climate change.

The interviewees were also asked about what areas should be prioritized for sustainable growth when comparing the city and the rest of the municipality. Interviewee 2 refers directly to carbon neutrality and risk prevention while interviewee 1 highlights the construction area, namely:
- attractive urban spaces that promote quality of life
- renewable energies (carbon neutrality by 2030)
- mobility and transport
- innovative and sustainable tourism

These statements justify the fact that, according to EDP (Eletricidade de Portugal) Lisbon, together with **Guimarães** (that, in 2020, has received the honor 100 Smart Cities, given by the European Commission) and Porto, were the selected Portuguese cities to participate in City Mission, from the European Union (EU), for innovation ecosystems, having in mind the neutrality of the climate's perspective by 2030. Research and

innovation actions reach areas such as clean mobility, energy efficiency, and green urban planning.[29]

After analysing the interviews in terms of content analysis a survey by means of questionnaire was developed to answer specific objective 3) To evaluate the congruence between what the decision makers are doing regarding the development of Guimarães as a smart city and the perspectives of the people who live, work or study there.
This questionnaire was developed to be answered by the residents of Guimarães. However, after discussing this issue, it was decided that it should be also extended to all those who study or work in Guimarães because they also have an opinion on the services the city offers, the environment, sustainability issues, links to businesses and other issues that would allow the city to be classified as smart.

The purpose of the survey by means of questionnaire was to find out how Guimarães is responding to the challenge of becoming an intelligent city, namely, to know whether the people who live, study or work there recognize the actions taken by the responsible for urban planning. This way we could respond to the specific objective 3 mentioned previously.

The questionnaire was available between the 24th May and the 28th June 2024 (see Appendix 3). In this case, the aim was to respond to specific objective 3), i.e. to evaluate the congruence between what the decision makers are doing regarding the development of Guimarães as a smart city and the perspectives of the people who live, work or study there, therefore an inside perspective.

Bearing in mind that we were looking for responses from individuals who lived, studied or worked in Guimarães, the respondents were selected by convenience using the snowball effect[30]. This way respondents would forward the questionnaire to individuals

[29] https://www.edp.com/en/smart-cities-what-and-why-are-they-cities-future accessed on 20 August 2024
[30] Literature states that a sample formed by convenience may not be representative of the population. Yet, because there are not lists of this population that could allow a random inquiry, we decided to

they identified as having one of the characteristics required (living, studying or working in Guimarães). Emails were therefore sent to friends and former colleagues. The questionnaire was also posted on the social networks of several people close to the author who fulfilled one of the required characteristics. Networks such as Facebook, Instagram and LinkedIn were used. There was also a need to complement the sample by approaching individuals in places where it was certain that people with one of the characteristics mentioned would be found. To do this, the author personally travelled to the University of Minho - Azurém Pole, a place he knows well as it was where he completed his degree in Geography and Planning in 2022. He created a QR Code to make it easier for people who were interested in answering to fill it in at that moment. A total of 116 responses were received, 101 of which corresponded to individuals with the desired characteristics (living, studying or working in Guimarães).

The questionnaire (Appendix 3) starts by asking permission to divulge the conclusions according to the general data protection regulation (RGPD).

"Do you agree with the collection of data to analyse and draw conclusions for research purposes?" (Y/N)
If the respondent agrees he/she could respond to the rest of the questions.

The following question regarded the sample filtering:
"Do you live or work/study in the municipality of Guimarães?" (Y/N)
If the respondent answers "Yes" he/she could respond to the rest of the questions. If not, the questionnaire ended.

The rest questionnaire was divided in two parts:

- personal data, and,
- respondents` perceptions
    - towards the importance that each respondent gives to each of the categories that the municipality uses to develop Guimarães (smart city)

pursuit using a non-random sample. Most of research is developed using non-random samples and that is a limitation.

- towards the importance that each respondent considers to be given by the municipality to the same categories

This way we could conclude the fit between the perceptions of the priorities considered by the respondents (people who live, work or study in Guimarães) and the developments of the municipality in what regards developing Guimarães towards a more intelligent city. These conclusions can give important cues to the decision makers and, eventually align their strategies and investments for we all agree that the "motor of the transformation" are the citizens as mentioned by interview 1 in the interviews.

In the end of the analysis of the survey by questionnaire we will be able to confront the conclusions with the ones from the interviews and meet the 3rd objective proposed in the beginning of this research and to evaluate the congruence between what the decision makers are doing regarding the development of Guimarães as a smart city and the perspectives of the people who live, work or study there, therefore an inside perspective.

The categories analysed by the respondents were mentioned in topic 7, i e, the 9 categories used by the city council:

- connectivity
- smart mobility
- energy and efficiency
- citizen participation
- waste management
- health and wellbeing
- digital education
- security
- smart tourism

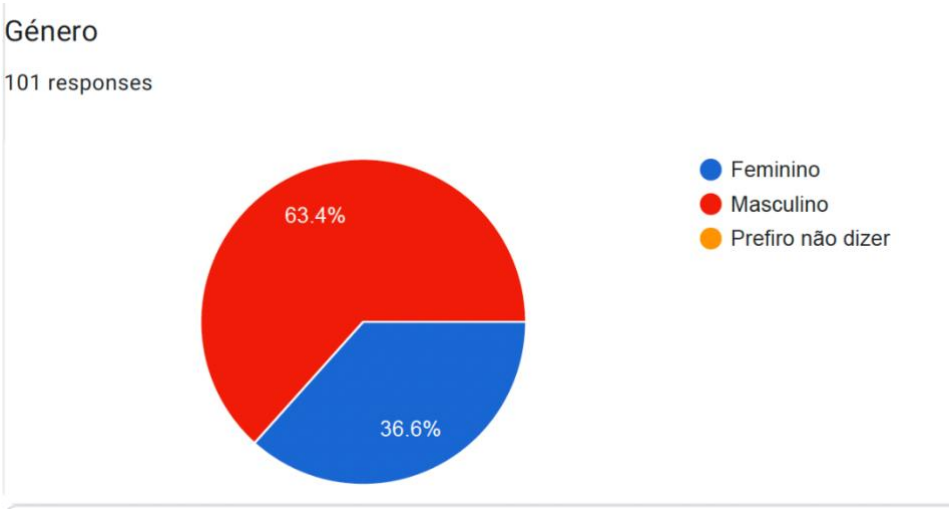
All answers were ranked from 1 to 5 using a Likert scale where 1 was the less ranked and 5 was the best ranked. There was a general question to be ranked concerning the opinion of the respondents about the evolution of Guimarães towards becoming a smart city. All these questions were mandatory except the last one – one open question where

the respondents were asked to provide suggestions or feedback about what they considered to be important in the context under study.

The results are as follows.

We begain by caratherizing the sample

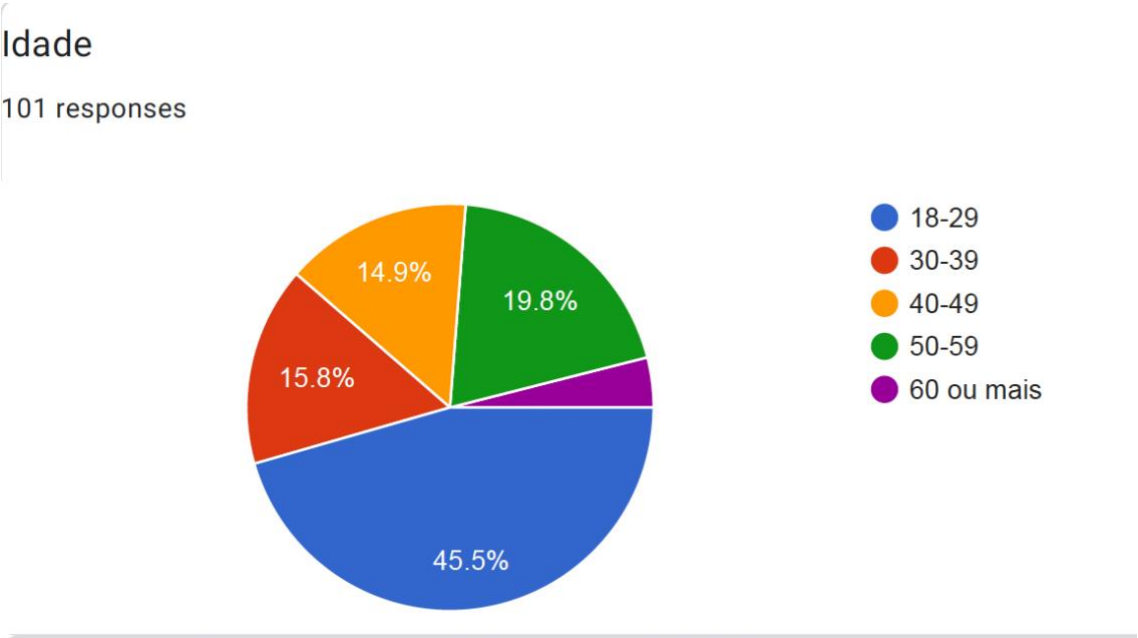
***Figure 6**: Gender*



Source: Own elaboration in https://docs.google.com/forms

The sample is formed by 63,4% of male and 36,6% of female.

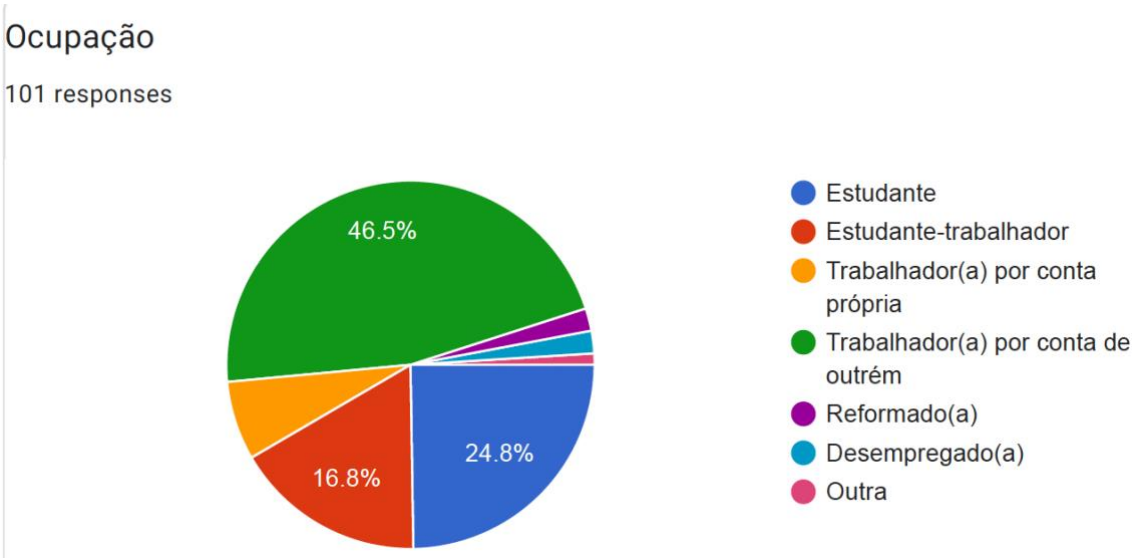
***Figure 7**: Age*



Source: Own elaboration in https://docs.google.com/forms

Most of the respondents have between 18-29 years old. This fact could be explained because the sample was generated by convenience and the author of this dissertation/report is 23 years old, so it is normal that his fellows are about that age.

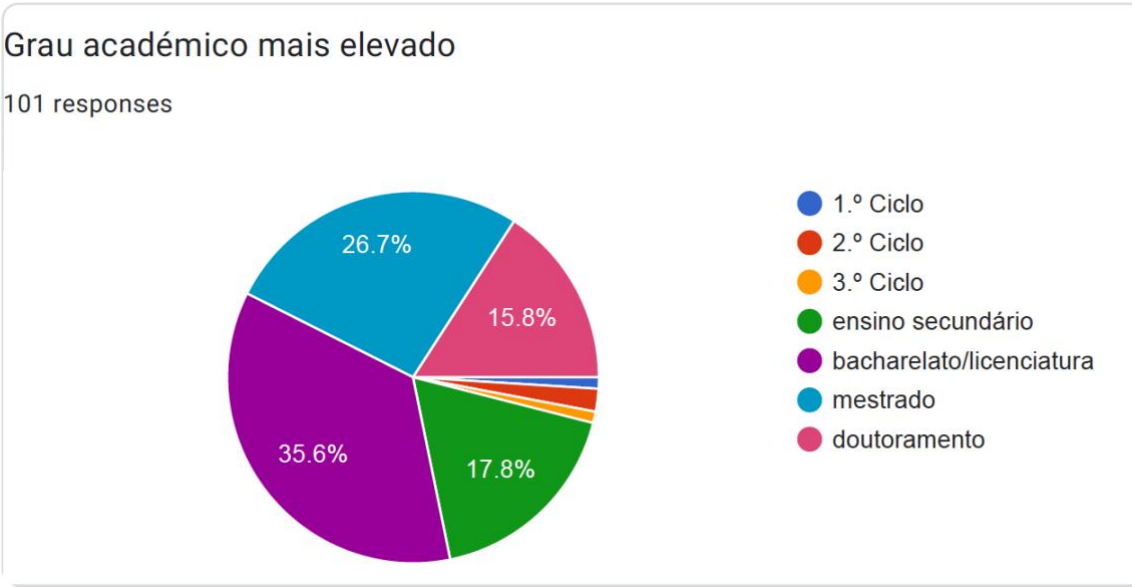
***Figure 8**: Occupation*



Source: Own elaboration in https://docs.google.com/forms

46,5% of the respondents are employees, 24,8% are students what can be explained because the proximity of the author to the academia, 16,8% are students that already are employed. Fewer categories refer to self-employed individuals, retired and others.

Figure 9: *Highest academic level of the sample*

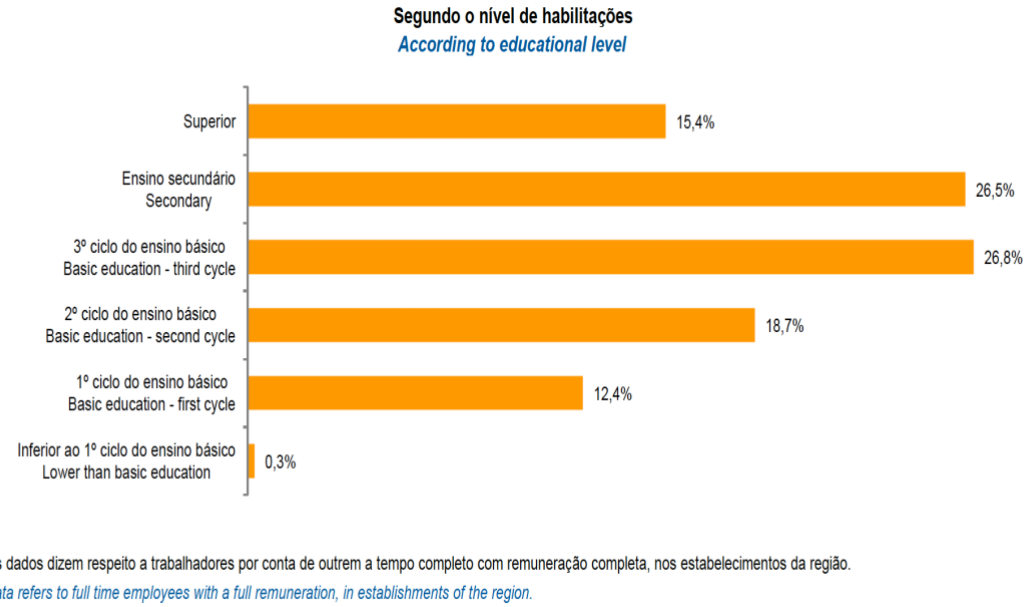


Source: Own elaboration in https://docs.google.com/forms

Most of the respondents have a bachelor's degree (35,6%), some have a master's degree (26,7%), 15,8% have even a PhD and 17,8% have completed high school. In this sample 80,1% of the individuals have a superior level (bachelor + master + PhD). If we compare this data with statistics developed by the Strategy and Studies Office of the Portuguese Republic, in 2020 this number was 15,4% as can be seen below in the figure.

Therefore, we are convinced that this sample might be influenced by the form of its extraction from the population.

Figure 10: Distribution of the population of the Guimarães municipality according to the educational level (2020)



Source: https://www.gee.gov.pt/pt/documentos/publicacoes/estatisticas-regionais/distritos-concelhos/braga/guimaraes/3017-guimaraes/file accessed on 2nd September 2024

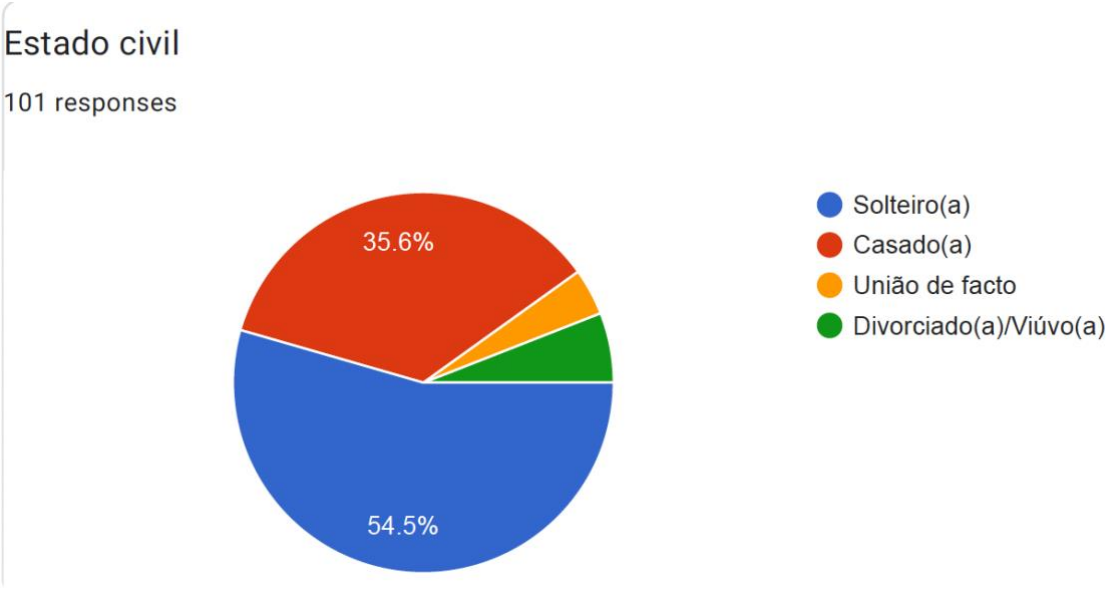
This sample was generated by non-random or non-probability methods. Statistically, only samples that are generated by random or probability methods are capable of represent the population and therefore the conclusions can be extrapolated to the population.

Yet, there are disadvantages of random or probability sampling strategies. One of the most mentioned is the fact that they present a significant challenge to execute. Also, the sizes of probability samples need to be quite large, often coming at great costs in terms of money, time, and effort. Moreover, designing probability samples requires substantial expertise (Jager et al., 2017). According to Bornstein et al. (2013) the most common non-probability sampling strategy used within developmental science is convenience sampling.

In line with what was mentioned, random or probability methods were not used in this study for two main practical reasons:

- very time consuming: it is easier to question people that are close to the researcher,
- there are no lists available of all the population under analysis (people who live, study or work in Guimarães) that could be used to select individuals randomly.

***Figure 11**: Marital status*



Source: Own elaboration in https://docs.google.com/forms

This sample is formed by 54,5% of single individuals, 35,6% of married, and a few divorced and even less living together as a couple.

About the perceptions of the respondents the questions posed were:

Rate from 1 (not at all important) to 5 (very important) the importance you attach to each of the following categories used for the classification of a smart city:

Connectivity: the network infrastructure and high-speed Internet coverage in the city and county.

Smart mobility: intelligent transportation systems such as electric public transportation, electric bike and car sharing systems and electric scooters, traffic management solutions to reduce congestion, integrated parking management, ...

Energy efficiency: technologies and practices for improving the energy efficiency of public and private buildings, promoting the use of renewable energies and intelligent energy management.

Citizen participation: Active participation in planning and in decision-making, using digital tools and platforms of online participation.

Waste management: smart waste systems, such as smart waste bins and recycling and more effective recycling programs.

Health and wellness: digital health solutions such as telemedicine and health monitoring to improve access to healthcare and promote healthy living.

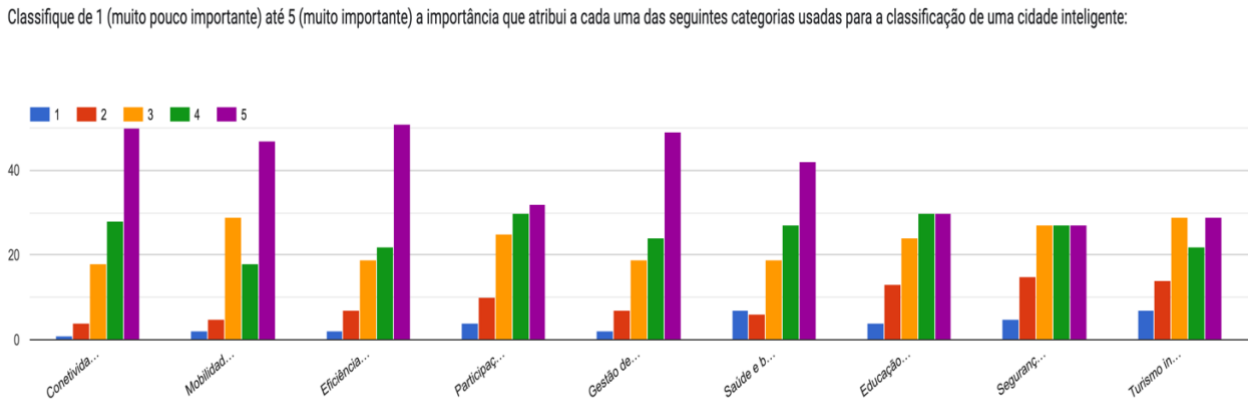
Digital education: Integration of technology in education, with access to digital devices and resources for students and teachers.

Security: Intelligent security systems, such as video surveillance and data analytics.

Smart tourism: use of technology to improve the experience of tourists by offering real-time information, virtual guides and tourism apps.

The results are as follows:

***Figure 12**:Rate from 1 (not at all important) to 5 (very important) the importance you attach to each of the following categories used for the classification of a smart city*



Source: Own elaboration in https://docs.google.com/forms

We can conclude that the respondents consider very important the following categories:

- Connectivity,
- Smart mobility,

- Energy efficiency,
- Waste management,
- Health and wellness.

Categories less valorised by the respondents:

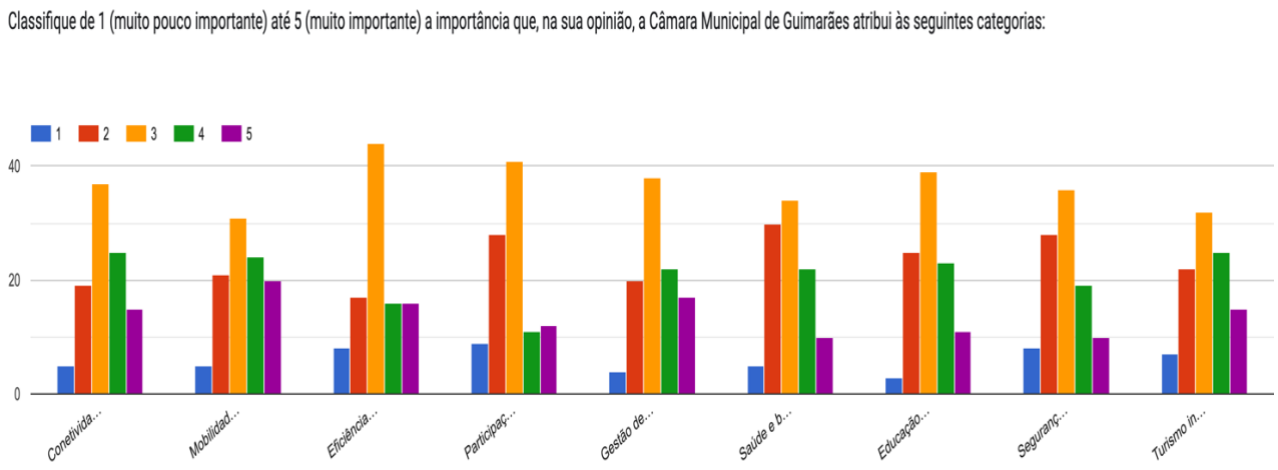
- Citizen participation,
- Digital education,
- Security and
- Smart tourism

are categories that are not considered as important as the previously mentioned.

It is strange that the respondents value less citizen participation for it is commonly featured as a manifestation of a solid democracy…

Then we asked the respondents to give their opinion about the importance they consider the municipality gives to the same categories.

***Figure 13**:Rate from 1 (very unimportant) to 5 (very important) the importance that, in your opinion, the Municipality of Guimarães attributes to the following categories:*



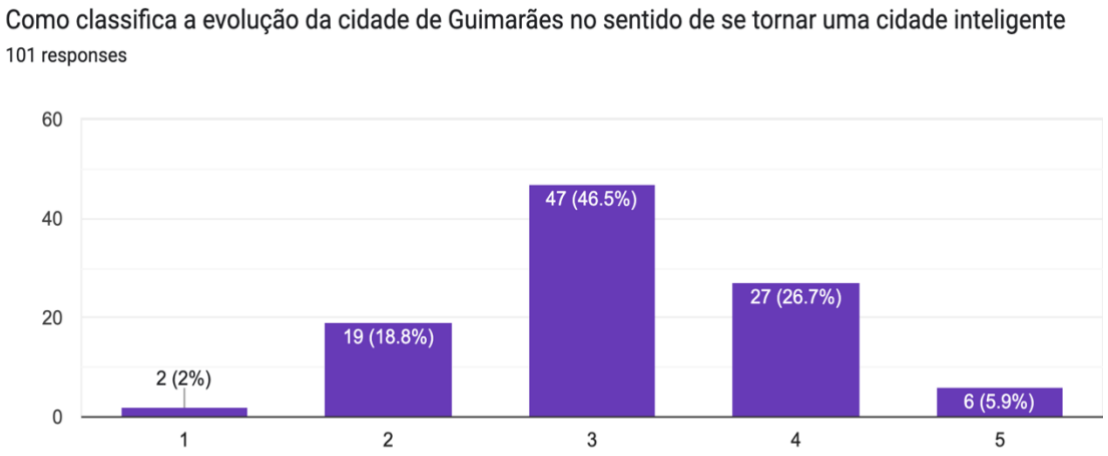
Source: Own elaboration in https://docs.google.com/forms

The respondents consider that the municipality gives responses to all the categories (1 has few choices) but probably should focus more on the categories that the respondents

value more. Yet, we may conclude that the respondents consider the actions of the municipality are recognized but could be improved

Respondents were asked to do a general evaluation about the evolution of Guimarães to become a smart city.

***Figure 14**: Perceptions on the evolution of Guimarães*



Source: Own elaboration in https://docs.google.com/forms

In a range from 1 (not at all achieved) to 5(very achieved) most of the respondents consider the evolution positive (47%+27%+6%) and only 21% consider that evolution insufficient.

The last question was not mandatory, and its intention was to provide suggestions or feedback or insights from the respondents. A summary of it is provided below:

***Table 12**: Suggestions of the respondents*

S1	There is much to do regarding governance and intelligent citizens
S2	Necessity of humanizing the city, thinking of people first instead of the automobiles and valorise/increase public participation
S3	There should be a faster train connection to Porto
S4	The discrepancy between what the City Council announces it is doing in terms of smart city and what happens should be studied
S5	The city would mainly benefit from developments in tourism
S6	Go back to the promotion of the electric scooters
S7	Buses should accept digital payment or app
S8	Metrobus would be ideal for a city like Guimarães.

Source: Own elaboration

In line with these results, we may conclude that generally there is a congruence between the importance given by the respondents and the importance given by the municipality to the selected categories. Nevertheless, there are some interesting and unexpected results in what regards the fact that the residents seem to value less the category citizen participation (commonly featured as a manifestation of a solid democracy as mentioned previously). Strangely there is one suggestion claiming to valorise public participation, therefore, probably some people value this category.

Confronting the conclusions from the interviews with the ones from the survey we may conclude that Guimarães is deeply engaged in developing smart solutions to improve its citizens quality of life namely in terms of carbon neutrality, smart mobility, waste and water management and providing rich experiences to the tourists. This engagement is achieved by a multidisciplinary team formed by the municipality, the academia (namely University of Minho and University of Trás-os-Montes and Alto Douro) and other relevant stakeholders like research centres in conjunction with the planning and territory use department of the city council.

In terms of areas that should be prioritized for sustainable growth when comparing the city and the rest of the municipality the interviewees highlited the importance of carbon

neutrality and risk prevention specially in the construction area focusing on attractive urban spaces that promote quality of life; renewable energies (carbon neutrality by 2030); mobility and transport and innovative and sustainable tourism. These statements are in line with some of the results presented in the survey and also with some of the mentioned suggestions provided by the respondents of the questionnaire. Nevertheless, there are few suggestions that might be considered critical to the political decisiors. One of the respondents mentions a mismatch between what the City Council announces it is doing in terms of development towards a smart city and what happens. Yet, this comment was only one of the eight suggestions in 101 valid responses.

In general terms we must agree in a congruence between the perceptions of the respondents between what the City Council announces and its achievements. One of the suggestions claims for increasing public (citizen) participation, yet this was one of the dimensions that appeared less valued by the respondents.

The suggestions also highlight some critics to some digitalization processes like “buses should accept digital payment or app”. This comment leaves space for improving the digital agenda.

There were two suggestions that should be analysed because, for an inhabitant of Guimarães it is commonly accepted that mobility could be improved. One of them is the future existence of a faster train connection to Porto and another one is the fact most users of public transportations consider that Metrobus would be ideal for a city like Guimarães. This way, we end this study by providing these insights to the decision makers.

Conclusion

There are many approaches to what a smart city is. Generally, there seems to be a dynamic from a more technological approach to a more holistic one, that loses its "smart" difference and embraces other buzzwords as "healthy city" and most especially sustainable city. Studying policies and cases put more light on how a smart city can be/is achieved.

This dissertation/report provides some contributions to the development of the theory on smart cities.

We begin by providing an overview on the activities that Guimarães is developing and intends to develop to become a smart city by comparing it with Pilot Studies on smaller smart cities among European Union and Europe. Comparison is always a complicate exercise as all cities are different. At the same time, they may learn from each other, and we may see different problems and priorities.

Towards being a more intelligent city Guimarães has been consistently developing a path evolving nine categories: Connectivity, Smart mobility, Energy efficiency, Waste management, Health and wellness, Citizen participation, Digital education, Security and Smart tourism. Regarding the comparison of Guimarães' path with that of other comparable cities and evaluating the road travelled we observe that Guimarães is a city committed to being a more intelligent, innovative and citizen-friendly territory. This can be evaluated by the great number of international activities where it is involved: integrated operations centres, a part of the Space4Cities consortium (fundings obtained from the HORIZON-EUSPA-2022-SPACE programme), aiming to develop and integrate intelligent systems using satellites to manage public spaces. Guimarães is one of 53 selected for the NetZeroCities Pilot Cities Programme (decarbonisation locally for two years); it is part of the Smart Portugal programme, and it was selected for the integrated edition of the Smart Portugal space…

This way Guimarães is in the European agenda towards being a more intelligent city.

Regarding the contributions to the field of studies in practical terms we evaluated the congruence between what the decision makers are doing regarding the development of Guimarães as a smart city and the perspectives of the people who live, work or study there. It might be concluded that generally there is a congruence between the importance given by the respondents and the importance they consider to be given by the municipality, considering to the selected categories. Beyond the general congruence unexpectedly the residents seem to value less the category “citizen participation” (commonly featured as a manifestation of a solid democracy!!!). In total misalignment with this there is one suggestion claiming to valorise public participation, therefore, probably some people value this category.

It was concluded that the respondents consider very important the Connectivity, Smart mobility, Energy efficiency, Waste management, Health and wellness. And they don´t valorise so much the Citizen participation, Digital education, Security and Smart tourism. The respondents believe that the municipality generally addresses all the categories, However, they suggest that more attention should be given to the categories they prioritize most (e.g. Connectivity, Smart mobility, Energy efficiency, Waste management, Health and wellness). Overall, it can be concluded that while the municipality's efforts are acknowledged, there is room for improvement.

We asked the respondents (people who live, work or study in Guimarães) to provide suggestions, and we must highlight two of them that we considered important: the urgency of a faster train connection to Porto and the use of Metrobus - ideal for a city like Guimarães.

For further research, considering the already mentioned constraints of the convenience sampling method, it would also be of great interest to complement this study with interviews to individuals that live, work or study in Guimarães. This complementary study could provide a more complete picture on their perspectives about the congruence between what the municipality develops and what the individuals perceive that is developed and needed.

It also could be interesting to develop another study that could include the external perspective, e.g. to ask visitors/tourists how they perceive Guimarães in terms of its path

towards a more intelligent city. Also of great interest would be to interview individuals that have already experienced other international cities comparable to Guimarães like Leuven, Limassol… or even other Portuguese smart cities as the ones mentioned by EDP[31].

All studies have limitations. There are theoretical and empirical limitations in this study. Regarding theoretical limitations the fact that we develop this study focused on indexes and rankings can be considered a limitation. According to Lazaroui and Roscia (2012) nowadays, although quite common, current rankings are very different in their approaches or methods. Most of them have quite specific aims focused on shareholder interests. Because of these different interests behind:

- rankings,
- used indicators and
- methodology approaches,

it is also normal that one city is ranked very different in various rankings… Additionally, medium-sized cities are often not considered when they are not recognized on a global level. This can be quite frustrating to cities that are developing their standards in line with sustainability and improving the quality of their residents as it is the case of Guimarães.

According to the same authors, for the ranking, a city sample selection is necessary. Considering the project's aim and its duration, a feasible sample should fulfil two criteria: - cities should be of medium size and - they should be covered by accessible and relevant databases.

In methodological terms the sampling method raises questions about the representativeness of the population and, therefore, the generalisability of the conclusions, yet, as explained previously non-random or non-probability methods are quite used in scientific research. Nevertheless, representativity is compromised and

[31] https://www.edp.com/en/smart-cities-what-and-why-are-they-cities-future accessed on 20 August 2024

therefore generalization is limited but the purpose of this dissertation/report is far beyond these constraints.

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Appendix

Appendix 1 - Smart cities provided from the smart cities IDM Smart Cities Index 2023

A more complete description of the smart cities mentioned in 4. Examples of smart cities, namely in 4.1 Smart cities provided from the smart cities IDM Smart Cities Index 2023.

4.1.1 Zurich

Zurich was ranked in the first place in the last 4 years by Smart City Index Report (2023), thus considering the smartest city in the world.

The municipal council fortifies and expedites the digital transformation of the city administration with the strategic emphasis Digital City (2019).

It makes advantage of digitization's potential for the good of the populace, businesses, and local government. For both the operators and the consumers of urban infrastructures, networking of data, sensors, and apps enables new and more effective solutions. Many initiatives are being planned or have previously been implemented in a variety of sectors.

The digital city consists of 6 sub-programs (Schrotter & Hürzeler, 2020). Zurich is implementing several digital initiatives to enhance its infrastructure and digitalization. The city is expanding its online services, including the "My Account" for taxpayers and companies, and implementing IT infrastructure in schools. The "Digital Inbox" project aims to digitize the city administration's physical inbox, allowing for seamless internal delivery, approval, and forwarding of letters. The city is also building its own city-wide network for IoT applications, and a "digital twin" platform will be created to enable location-based collaboration with stakeholders. Open Government Data (OGD) will be developed according to the principle of "Open by Default" and a city-wide governance policy will be developed to regulate data handling. The SSP "Digital City" aims to build digitalization expertise among municipal employees, making daily work with IT

applications easier and identifying and utilizing the potential of digitalization in the city. (Strategie-Schwerpunkt “Digitale Stadt” - Stadt Zürich, n.d).

4.1.2 Oslo

The Norwegian capital was awarded the European Green Capital 2019 title by the European Commission and ranked at the second smartest city in the world over the last 4 years according IMD Smart City Index Report 2023.

Since the 90’s, Oslo has introduced the Oslo Toll Ring. This automated toll system is no more than a incentive for zero-emission vehicles and then generating revenues that part-finance the smart city’s mobility programs as the public transportation, cycle and pedestrian infrastructure. (Oslo, an Inclusive Smart City, n.d.).

Nowadays, Oslo is the world leader in electric car, setting up a global record this year when it sold almost one in three completely electric new automobiles, despite the nation's plans to outlaw the sale of cars with internal combustion engines starting in 2025. Norway has also eliminated most of its tariffs on electric vehicles and is providing other incentives, such free parking and charging stations, to reduce carbon dioxide emissions and air pollution. (Knudsen C. & Doyle A., 2019).

The construction projects must have genuine urban and architectural excellence, have a 50% carbon footprint reduction, and be situated close to a public transportation hub to be authorized by FutureBuilt and an empathizes on mobility as key concern for that city.

Among these projects there is an example as the passive energy design model Bjørnsletta school, housing 800 students, is one of these projects. It includes completely automated interior climate control and energy management systems. Car parking has been purposefully limited, with bike parking taking precedence.

Another key for Oslo is the public and private partnerships embracing innovations such as trenchless installation of water pipes, using techniques that have been tried and tested in the oil industry. The projects are shorter and less disruptive to traffic and local residents. (Oslo, an Inclusive Smart City, n.d.).

4.1.3 Canberra

Through cutting-edge initiatives like the CBRfree WiFi network, one of Australia's largest free outdoor public Wi-Fi networks, and an integrated smart parking network that is currently being trialed in one of our boutique shopping districts, the ACT Government is committed to transforming Canberra into a smart and connected digital city. To guarantee that Canberra continues to be the most livable city in the world, the ACT Government's smart city initiative makes use of smart partnerships, smart policies, and smart technology. (Canberra, n.d.)

In addition to strengthening the Territory's response to climate change and promoting sustainable living and resource use, the Environment, Planning, and Sustainable Development Directorate offers a planning and land use system that supports the ACT's sustainable development. The Directorate's mission is to spearhead the Territory's development and execution of focused policies and initiatives pertaining to water and energy security, historical preservation, sustainable urban design, sustainable transportation, and sustainable spatial planning. (Canberra, n.d.).

With these measures, Canberra attained a third place for smartest city in the world in 2023, according to the Smart City Index Report.

4.1.4 Copenhagen

“The green growth city” Copenhagen's smart city plans are aimed at being carbon neutral by 2025. The city aspires to increase its attractiveness on a European and worldwide scale. Copenhagen's Green Growth initiative promotes sustainable transportation alternatives. The city's high vehicle fees have altered commute habits and fostered bicycle culture. Copenhagen is using intelligent solutions to become a pioneer in smart city technologies. The city encourages open data sharing and partnership with private enterprises to develop creative solutions. Mobility projects seek to minimize CO2 emissions and promote sustainable mobility. Copenhagen intends to become Europe's first carbon-neutral metropolis by 2025 (Quelin & Smadja, 2021).

4.1.5 London

The smart city initiatives of London are organized under the Smart London platform, directly under the governance of the mayor of London.

The most relevant project “Smarter London Together Roadmap” focuses on user-designed services, data sharing, connectivity, and digital skills. There is an emphasis on collaboration and partnership for innovation and the benefit of Londoners. The project also promotes diversity in tech, data rights, and accountability for trust. City data is used to provide public services and address urban concerns. Public assets are used for connectivity and infrastructure development. It is also importance of digital leadership and capability within the public sector. It promotes digital skills training and the talent pipeline for Londoners, including digital learning programs for youth. Digital technologies are utilized for public participation and planning processes, in partnership with the GLA Group and other organizations working on digital transformation (Greater London Authority, 2018).

4.1.6 Singapore

Singapore belongs to the top seven smartest cities in the world and the best in Asia according to IDM Smart City Index Report 2023.

Prime Minister Lee Hsien Loong launched the Smart Nation program in 2014, and three years later, the government invested SGD$2.4 billion (then equivalent to US$1.73 billion). It has implemented a diverse set of smart technology in both the public and private sectors (Thales, 2023). The goal is to build a city powered by digital innovation and technology that can adapt to inhabitants' changing requirements (Thales, 2023).

Singapore's government has developed plans to transform its economy, government, and society through the Digital Economy Framework for Action, Digital Government Blueprint, and Digital Readiness Blueprint. The Digital Economy will shape the Digital Economy and a Digital Society, while the Digital Economy will support digitalization of government service delivery and industry capability. The government is also working on a holistic approach to cultivate a Digital Society capable of harnessing technology (Smart Nation and Digital Government Office, 2018).

Singapore's high-density city has implemented sensor technology to optimize transport efficiency, including an autonomous fleet for elderly and disabled residents, self-driving shuttles for students, and an electronic road pricing system to manage traffic congestion. A trial using public data, including fare cards and bus tracking, has reduced over-crowded buses by 92%, aiding in transport optimization (Thales, 2023).

Singapore is implementing contactless payment technology to streamline public transport movements for 7.5 million passengers daily. The city is also running a Smart Mobility 2020 initiative to enhance travel experiences through intelligent transport systems. The Travel Smart Program encourages citizens to rethink travel habits, such as cycling and remote work, to distribute peak hour demand more evenly (Thales, 2023).

Singapore's e-health initiative aims to improve the quality and accessibility of healthcare services for the ageing population by 2050. The initiative, led by the Ministry of Health and the Infocomm Media Development Authority, includes HealthHub, telemedicine, and TeleRehab. HealthHub allows patients to manage their health, while TeleRehab allows patients to perform exercises at home using wearable IoT devices. Singapore's ageing population is also being assisted by robotics, such as AI-powered chatbots and the Smart Elderly Alert System, which monitors and learns people's movements for urgent care (Thales, 2023).

According to the 2023 Legatum Prosperity Index, Singapore placed first out of 104 nations in the "health component" category, which assesses how healthy people are and how easily they can receive the resources they require to stay well (International Trade Administration, 2022).

The Smart Nation app, developed by Singapore's government, offers citizens a one-stop platform for accessing government services and information. With 90% of the population owning smartphones, the app simplifies citizen interaction with the government. It features digital identity creation, government services, feedback reporting, personalized information, and real-time updates on emergencies. The app is crucial for citizens to stay connected with their government and access essential services and information (Thales, 2023).

Singapore's Punggol Digital District, combining the Singapore Institute of Technology with a business park, aims to promote cybersecurity and IoT technologies, establish a data-sharing collaborative, and enhance cybersecurity through CorpPass (Thales, 2023).

Singapore is utilizing artificial intelligence in education through its TechSkills Accelerator program, with initiatives like AI for Everyone and AI for Industry supporting upskilling of 12,000 professionals and students. The city also offers a digital national identity system and a 3D virtual model (Thales, 2023).

Singapore is also a sustainable city. Singapore's Tengah project will build new homes and workspaces alongside Jurong Innovation District and Jurong Lake District. The 'forest town' will feature a 100-meter-wide corridor connecting nature reserve, water catchment area, wildlife passage, and recreational space. Residents will have access to buses and the Jurong Region Line, and Tengah will be the first Singaporean development with a car-free town center (Marchant, 2021).

Singapore's Housing & Development Board is working with power company SP Group to design Tengah as a smart energy town. The town will feature computer simulations to optimize wind flow, smart lights, a centralized cooling system, and automated waste collection. The system aims to reduce energy consumption and create a cleaner living environment (Marchant, 2021).

Overall, Singapore's success as a smart city may be credited to its ability to use technology to improve inhabitants' quality of life while simultaneously focusing on sustainability and efficient government. Singapore has built a leading smart ecosystem that puts residents first, thanks to data- and technology-driven projects like these (Thales, 2023).

4.1.7 Helsinki

Helsinki, named the European capital of smart tourism in 2019, boasts the best digital twin, the most innovative region, the best European mid-sized region for foreign investments, and the fifth and eighth best smart city globally (Shamsuzzoha et al., 2021). Forum Virium Helsinki has 81 projects involving 750 companies, 170 research facilities, and 60 partner cities. The projects are grouped under four main headlines: IoT, Smart City, Smart Mobility, and Forum Virium. The aim is to make Helsinki the most functional smart city globally. IoT projects focus on disruptive ICT technologies, while Smart Mobility projects include drone transportation, autonomous vehicles, and autonomous minibuses for last-mile delivery (Virium, 2020).

Helsinki's vision is to be the world's first city to provide a fully integrated personal mobility-as-a-service system. The region extends an open invitation to Finnish and international enterprises to engage in pilot programs and promote their solutions in the Helsinki region.

The “Smart traffic of Helsinki” evolves the Forum Virium's Smart Mobility initiative, which focuses on four main research themes: low carbon energy usage, advanced vehicle development, smart mobility services, and transport systems, including drone and electric autonomous minibus trials (Virium, 2020).

4.1.8 Hamburg

The Smart City Lab in Hamburg focuses on local district management services for energy, mobility, and public involvement. The goal is to help local actors, such as small and medium business owners, facility managers, local utilities, and prosumers, develop new business. With our use cases for smart energy, urban transportation, and IoT-BIM (Building Information Modelling) simulations, we are demonstrating new business models and merging various technologies and platforms to establish a system-of-systems approach. This service is available to all stakeholders and knowledge holders.

4.1.8 Stockholm

More recently Stockolm as a smart city launched the Stockholm Smart City Conference & Expo for May 22 and 23, 2024 to business executives, entrepreneurs, professionals, authorities, politicians, decision makers, and academics from around the Nordic countries convene to learn from one another, exchange experiences, discuss best practices, and explore new avenues for international collaboration.

The emphasizing challenges of this event include Digital technologies such as AI, IoT, 5G/6G, cybersecurity and data virtualization; Smart construction, innovative materials and a more efficient infrastructure; Safety and security are top concerns in both the physical design of cities and in the design of a digital infrastructure; automated and connected vehicles and personalized and shared mobility; and the access to sustainable, reliable and renewable energy, and the promotion of a circular economy.

4.1.9 Amsterdam

Amsterdam Smart City focuses on a smart, green, and healthy future for the Amsterdam Metropolitan Area, focusing on a values-first approach and utilizing data and tech to improve quality of life. The city views tech as a means, not an end, and encourages open knowledge sharing.

Amsterdam Smart City is an open innovation platform that fosters cooperation and collaboration among companies, knowledge institutions, governments, and residents to address metropolitan challenges and solutions, ensuring better streets, neighborhoods, and cities in a transitional world.

Amsterdam Smart City is part of the Amsterdam Economic Board, the organization that works on the future of the Amsterdam Metropolitan Area, who works also into private-public partnerships within governments, knowledge institutions, social organizations, and innovative companies.

4.1.10 Seoul

Seoul, the capital of the Republic of Korea, achieved a high score in the McKinsey Global Research Institute's 2018 review of smart city technologies. Seoul created the Smart City and Digitization Master Plan in accordance with the vision "Seoul, Leading the Future of Digital Transformation as a Global Smart City". The master plan, which will be implemented between 2021 and 2025, includes city initiatives to enhance smart infrastructure, increase non-face-to-face public service delivery, and promote the digital economy. Seoul recently has chosen to include the metaverse platform into its smart city concept, revealing a master plan to create a metaverse platform for the local administration. The "Metaverse Seoul" platform will enable access to a variety of governmental services while also strengthening citizen rights in virtual space (James W, Elston D, 20 C.E.).

4.1.11 Dubai

To improve Dubai as a smart city, recently the main goals of the Dubai 2040 Urban Master Plan are to modernize Dubai's urban areas, increase the effectiveness of

resource utilization, create lively, inclusive, and healthful communities, double the amount of green space and recreational areas, offer a healthy environment to both locals and tourists, and provide sustainable and adaptable transportation options.

The emirate's seventh development plan since 1960 is the Dubai 2040 Urban Master Plan. Dubai's population expanded from 40,000 in 1960 to 3.3 million in 2020, an 80-fold rise, while the emirate's built-up area increased from 3.2 square km to 170-fold.

The last master plan of Dubai before the current one was Dubai Master Plan 2020. Dubai Municipality include that this project is based on strategies pertaining to population increase and sociodemographic transition, efficiency of use of infrastructure resources, a thriving economy with security for investments, encouragement of ecologically responsible and effective energy sources and enhancing the regulatory and legal environment that facilitates the urban planning procedure.

The current master plan was launched on March 13th, 2021 (WAM).

The Dubai 2040 Urban Master Plan a comprehensive plan for a sustainable urban development in Dubai.

Over the next 20 years, it aims to improve people's happiness and quality of life while securing Dubai's position as a top global travel destination for citizens, residents, and tourists.

The Dubai 2040 Urban Master Plan outlines key objectives for the city's development, including upgrading various urban areas such as Deira, Bur Dubai, Downtown, Business Bay, Dubai Marina, JBR, Expo 2020 Centre, and Dubai Silicon Oasis Centre. The plan aims to enhance resource utilization efficiency, create vibrant and inclusive communities with increased green and leisure spaces, promote sustainable and flexible mobility options, stimulate economic activity, and attract foreign investments in new sectors. Additionally, the plan emphasizes environmental sustainability, preservation of cultural and urban heritage, and strengthening citizens' connection to older neighborhoods. It also involves developing comprehensive legislation and a governance model to support sustainable development and growth.

About the outcomes by 2040, Dubai aims to achieve significant milestones, including doubling the size of green and recreational spaces, with nature reserves and rural areas constituting 60% of the emirate's total area. The establishment of green corridors will connect service areas, residential zones, and workplaces to facilitate pedestrian, bicycle,

and sustainable mobility movements across the city. Land areas dedicated to hotels and tourist activities will increase by 134%, commercial activities will expand to 168 square kilometers, and education and health facilities will see a 25% increase. Public beaches' length is expected to grow by 400%, reflecting a comprehensive plan for the city's development and enhancement of various sectors.

The Master Plan intends to promote the use of flexible mobility options, walking, bicycling, and public transportation in addition to creating an extensive planning database to aid in decision-making and improve transparency. (UAE government, n.d.).

4.1.12 Hong Kong

The “Hong Kong Smart City Blueprint 2.0.” acts as a communication link between the government and the public, delivering real-time city data dashboards and information on smart city projects. Initiatives include the implementation of new electronic payment systems, real-time traffic signal systems, crowd management systems, and smart recycling initiatives. There are efforts to improve smart environment projects such as waste management, pollution monitoring, and noise reduction. Smart government programs are focused on establishing automated processes, using advanced maintenance technologies, and enhancing public services through technology adoption and open data. The goals include fostering digital transformation in the corporate community, recruiting entrepreneurs and investors, and establishing Hong Kong as an inventive and technologically sophisticated location (OGCIO, 2020).

4.1.13 Vienna

Vienna's urban development history has contributed to the city's exceptional quality of life. However, emerging concerns, such as the climate catastrophe, necessitate novel answers (Deistler & Homeier, 2022).

In 2014, the Vienna City Council set an initial milestone for tackling the causes of climate change and dealing with its repercussions with the Smart City Wien framework strategy. The Smart City Vienna strategy aims to reduce CO2 emissions, energy consumption, and promote innovation. The Vienna Smart City project integrates energy monitoring, plant

control, and user involvement to reduce energy consumption and CO2 emissions. Vienna's Smart City initiatives focus on addressing sustainability issues through urban management models and long-term strategies. The "Make Your City Smart" project develops a toolkit for construction initiatives in Vienna Aspern to support sustainable urban development (Roblek, 2019).

Vienna aspires to have a resource-efficient circular economy by 2030. The city prioritizes the transition to renewable energy generation. Urban mobility programs prioritize public transit and renewable transportation choices. Implementing greening techniques in buildings and public areas is critical to combating climate change. Vienna prioritizes land efficiency, biodiversity, and urban agriculture. The Smart City Wien program depends on public participation and innovation to achieve sustainable urban development (Deistler & Homeier, 2022).

4.1.14 Barcelona

Barcelona, a city more than 2,000 years old, provincial, and marginal, without the capital of an important monarchy or state, with practically no public spaces, walls and an extremely dense grid, a style of urban planning common in the Middle Ages. It also had interior open spaces as was common in the medieval Arab city (Narciso, 2008), since the city was colonized by the Arabs until September 11, 1714 (Pra Entender Barcelona: História Da Catalunha, 2021).

During the height of the industrial revolution in the first half of the 20th century, Barcelona had to change its approach to urban planning. It was then that Ildefonso Cerdà (1959) began the 'Ensanche', which is his main work (Narciso, 2008).

Cerdà developed three basic components: the hygienist will, circulation and the "new city". The hygienist will be based on the urban situation at the time, with a geographical and urbanistic analysis. Circulation is movement, which generates a hierarchy of streets and major intersections in chamfer. The "new city" is a condition of equality between residents. Garcia Faria's 1891 project is based on a study of Barcelona's holistic sanitation, which was conceptualized by Cerdà. As for the Leon Jaussely's 1907 project addresses the need for an urban constitution in Barcelona, incorporating municipalities

and formalizing connections through zoning activities, systematizing green spaces, and designing streets and sidewalks, enhancing Cerdà's ideas (Lemos, 2011).

However, during the 20th century many of these projects have deployed later due the social, politic, and economic causes (Ajuntamento de Barcelona, 1992).

Many of these measures started to be put into effect starting in the 1990s and the Barcelona 1992 Olympic Games have been an opportunity.

According to Baciki et al. (2013), there are several general characteristics of the smart city project that Barcelona is proposing: the democratization of information access; the intersection of public and private; citizen participation as a crucial component in the planning and definition of the city model; the dissemination and use of information and communication technologies (ICTs); the applicability of the living lab model; management focused on the smart city model; and the implementation of smart districts, specifically the 22@ project.

In the Poblenou neighborhood, the 22@Barcelona project was developed in 2000 with the goal of revitalizing the industrial regions both urbanely and economically (22@Barcelona, the Innovation District, n.d.).

District 22@ is a mixture of urban projects and pre-existing buildings that serve as a historical synthesis of the Cerdà Plan and the GATCPAC Macià Plan. The "macro-block", which seeks a higher hierarchy in the road system of three-by-three blocks, and a renewed conception of construction, more open and with more free spaces, is implemented in some areas of the regular Ensanche square. The continuation of the Diagonal to the Forum is another step towards the transformation of the north-eastern end of the city and the adoption of the Cerdà Plan (Lemos, 2011).

4.1.15 Rotterdam

The case focuses on platform purpose, governance, finance, trust, and citizen involvement via the OUP (open urban platform) by city management, as well as the opportunities for innovation in this Dutch city. The case is part of the EU Horizon 2020 Smart City project RUGGEDISED, which includes Rotterdam as a lighthouse city. The goal of this project is to create smart, resilient cities by developing and implementing smart solutions in energy, e-mobility, and ICT. The RUGGEDISED project's overall goals are to

improve citizens' quality of life, reduce environmental impacts of activities, and foster a stimulating environment for long-term economic development. The case was tested in an educational setting and then improved (Bagheri, 2024).

Rotterdam's 'Hart van Zuid' Smart Grid connects various clean energy solutions, including a thermal Smart Grid with deep underground aquifers. Sensor technology ensures optimal energy distribution, proving large-scale integration is profitable and effective. Rotterdam Ahoy, a local venue, is the biggest beneficiary of the Smart Grid, now free of fossil-fuel-based energy sources.

4.1.16 Tokyo

Tokyo hosted its first global smart cities event, City-Tech Tokyo, in February 2023. The event attracted thousands of participants from government, academia, and industry to discuss smart cities for a sustainable future. Tokyo Governor Yuriko Koike invited startups and companies to explore the city as a proving ground for their products or services. The conference featured pitch contests, business meetings, and 300 startup booths, aiming to be the most startup-friendly city in the world by 2040. A delegation of smart city leaders from the U.S. attended and spoke at the event. Panelists discussed partnerships between cities, regions, national levels of government, and other public and private sector organizations for creating smart and resilient cities. The event also featured discussions with Mr. Takehiko Nagumo, Executive Managing Director at Smart City Institute Japan, and Dr. Philipp Aeby, CEO at RepRisk, on improving people's well-being in digital governments and smart cities. The event was held in Tokyo, showcasing the city's quiet and clean environment, green space, and efficient public transportation (Collier, 2023).

4.1.17 Melbourne

In Melbourne, the City of Casey has had a smart city strategy in place since 2017. Additionally, the City of Melbourne, Wyndham, and Greater Geelong have launched smart city portfolios. Melbourne's three agencies are presently creating smart city initiatives. The middle-ring suburbs of Melbourne are experiencing urban development,

with a concentration on smart/digital city projects. Greater Geelong and the City of Melbourne run open data portals. Local governments in Melbourne are investing heavily in technology as part of their smart city ambitions. These programs reflect Melbourne's rising emphasis on smart city development and technology integration (Dowling et al., 2019).

4.1.18 New York

The smart city journey in New York City (NYC) began in 2007 with the vision set by PlaNYC for NYC through 2040. Data collection across ten focus areas such as energy, climate change, and air quality started to improve policy. In 2010-2013, NYC developed its first digital strategic plans, paving the way for leadership in smart city technology. The current unified city plan, OneNYC, integrates initiatives for diversity, inclusivity, equity, growth, resiliency, and sustainability. NYC's smart city roadmap includes strategies for a sustainable future, such as greenhouse gas emission initiatives and energy efficiency policies like the 2019 NYC Buildings Emissions Law. The city is committed to a 0x30 recycling goal and program. Various smart city projects have been implemented in NYC, including connected vehicle technology and smart street lighting. Local ecosystems in NYC involve organizations investing in innovative technologies. The roadmap provides insights into NYC's vision, strategies, challenges, and key actors involved in sustainable urban development.

4.1.19 San Francisco

San Francisco is renowned for its innovative technology and smart city initiatives. It has implemented various smart transportation systems, such as real-time data optimization, contactless payment systems, and bike-sharing schemes. It has also improved energy efficiency in buildings through retrofitting with energy-efficient technology. IoT technology has been used to monitor air quality and optimize city services. San Francisco has developed a smart city platform that integrates city data and services to enhance citizens' lives. Intelligent surveillance systems have been implemented to detect and respond to potential security threats in real time. An extensive network of electric

vehicle charging stations has been established to promote electric vehicle use. San Francisco has also implemented smart street lighting systems that adjust the brightness of street lights based on time of day and pedestrian and vehicle presence. A smart waste management system uses IoT technology to optimize waste collection and disposal. San Francisco is also promoting the use of renewable energy sources like solar, wind, and hydropower to reduce carbon emissions (Smart City San Francisco, 2023).

4.1.20 Osaka

Plug and Play, a global venture accelerator, has expanded to Osaka to address social issues such as demographic structure, building revitalization and natural disasters. The company plans to launch an accelerator program focused on smart cities in Japan, aiming to make the Keihanshin metropolitan area one of the world's leading startup ecosystems. The company has already implemented five programs in Japan, accelerating over 400 startups with 43 corporate partners. The first program will focus on smart life and construction, travel and experiences, urban mobility and cleantech, hospitality and health. The second and third programs will focus on IoT, fintech, Insurtech, mobility, brand & retail, health, smart cities, and new materials and energy. Plug and Play will hold its Osaka accelerator program with domestic and international companies who want to incorporate new urban solutions using advanced technology.

4.1.21 Abu Dhabi (Masdar)

Masdar City was founded with an inaugural event in 2006. The Masdar Smart City is located just a stone throw away from Abu Dhabi (capital of United Arab Emirates). This city intends to become “the first zero carbon city in the world”.

The bigger investments had taken a place in 2016 (Pinto, 2017). Masdar City, a 640-hectare project in Abu Dhabi, aims to create a carbon-neutral desert community with zero waste. The project is part of the Masdar Initiative, a government initiative to develop renewable energy and clean-technology solutions. Masdar City is a mixed-use, low-rise, high-density development, linking to Abu Dhabi's transport infrastructure and international airport. It is the first modern community without fossil-fueled vehicles at

street level and will feature wind and photovoltaic farms, research fields, and plantations.

Masdar City utilizes GPS and GIS technologies for efficient transport planning and land use alignment. The city focuses on using GIS for construction processes, monitoring systems, and energy and transportation networks. Siemens Middle East headquarters in Masdar City features advanced technologies like automatic temperature and lighting adjustments. The building incorporates security, fire alarm, and gas suppression systems for employee safety. Masdar City faces challenges due to hot desert climate, leading to innovative energy management solutions. The city employs energy-efficient techniques like natural light, insulation, and window-glazing to reduce energy consumption. Masdar City showcases smart home farming solutions with the "Bustani" concept in eco-villas. The initiative promotes self-sufficiency and food security through IoT technologies for food production and waste recycling (Sankaran & Chopra, 2020).

4.1.22 Cairo (New Cairo City)

Up to $11.2 billion is anticipated from China to build Egypt's new administrative capital, which will be close to Cairo.

Among the initiatives that will receive Chinese support are the development of a satellite for Egypt and an electric train project connecting Salam City in Cairo with the new administrative capital.

The New Cairo capital city is 35 kilometers east of Cairo and covers a total area of 725 km2. The new capital is located between the regional ring road, Cairo-Suez and Cairo-El Ain El Sokhna Roads. It is a city designed for 6.5 million inhabitants. The new capital city will serve to develop and diversify the country's economy by providing new areas to live, work, and visit. To attract residents to this new capital city, a number of significant catalytic developments will be built at its core. This will contain a new government administrative district, a cultural district, and a diverse set of urban neighborhoods. The new capital is being built with the strategic objective of being a smart city that integrates its smart infrastructure to deliver a wide range of services to inhabitants such as smart traffic, utilities, buildings, energy management, a connected city and a safer city covering up all districts with CCTV cameras and control sensors.

According to Egyptian media, the country has set high hopes for the construction of the new capital to alleviate population pressure on Cairo, improve transportation, create jobs, attract foreign investment, and improve the country's image.

However, Fernandes (2022) says: “Cairo will no longer be the capital of Egypt. President Abdel Fattah al-Sisi has undertaken the construction of a New Administrative Capital (NAC), an absolutely megalomaniac city where only the elite will have a place. This is a strategy by the current regime to concentrate power and prevent demonstrations similar to those that took place during the Arab Spring in 2011”.

It’s a bit controversial due roughly 60 % of Egyptians are living in poverty (Arezki, 2023) and the deployment of a New Administrative Capital may be no more an excuse to prevent protests as the Arabic Spring in 2011 and remain the power of the elites (Fernandes, 2022).

4.1.23 Medellín

Medellín was considered as the best innovative city for the year 2012. It has developed ICT based infrastructure and conducted several workshops with low-income classes to facilitate them with free Wi-Fi and access to digital education. (Mehmood et al, 2023).

There are also 9 smart city completed projects in Medellín as “MiMedellín” a virtual platform created in 2013 where residents can voice and share their thoughts to help the city change. In 2014 was created the “Comunainnova” when universities and research groups have contributed to the creativity and change of Medellín's communities. According to RutaN (2016), 2 projects were created like a green corridor close to line B of metro of Medellín in Ferrocarril Avenue and the Innovation Laboratory “to materialize innovation processes through agile methodologies and tools that facilitate the target audience the definition of new business opportunities”. The fifth one is the “Metrocable Picacho”, who has begun in 2017 and ended up in 2021 and this project is settled to improve citizen’s mobility in some neighborhoods. The last one was made in 2019 and its name is “MeData” who emphasizes improvement the quality of life and citizen involvement in the problems and development of their city (Salgado & Jaramillo, 2019).

Appendix 2 – Interview guide

English version:

SEMI-STRUCTURED INTERVIEW

Purpose of the interview: to explore the potential opened by the Smart City concept: discussion of the concept - what is a smart city and what should it be, and, evaluation of the path taken towards making Guimarães a smart city.

QUESTIONS

1) Smart cities have been defined very much based on the technology that allows them to connect, between citizens and various entities (municipality, health center, educational institutions...). In your opinion, what is the main objective of a smart city?

2) In this field, with which European cities do you consider Guimarães to be comparable? Or what European (or non-European) cities can be used as guidelines for developing Guimarães as a smart city?

3) In your opinion, how important and interesting is it for Guimarães to develop a path towards becoming an increasingly intelligent city?

4) How do you assess the path Guimarães has already travelled towards becoming an increasingly intelligent city?

5) In your opinion, considering the recent measures taken, for example, in terms of separating organic and common rubbish, and those that are expected to be taken soon in terms of energy efficiency, namely achieving 100 per cent of public lighting using LED luminaires, how do you see Guimarães growing to become an increasingly intelligent city? What is missing? What opportunities are there for improvement?

6) How do you assess the growth already achieved by Guimarães as a smart city when compared to other cities of a similar size and characteristics, namely based on the realizations made in the year 2023?

7) How are decisions made regarding Guimarães' development priorities at this level? Are international studies analyzed, regional studies developed? Do you use experts in the field, or do you use the existing competences of the City Council, particularly in the Urban Planning department?

8) Which areas do you think should be prioritized in Guimarães in the field of the smart city?

9) When comparing the city and the rest of the county, which areas would you consider priority for sustainable growth?

CHARACTERISATION OF THE INTERVIEWEES

- age:
- gender:
- highest academic qualification:
- number of years working/dealing with issues related to urbanism and/or smart cities:
    - Outside Guimarães:
    - In Guimarães:
- what is your current role (tasks, responsibilities) in the field of urban planning with a view to the smart development of Guimarães.

Portuguese version:

ENTREVISTA SEMI-ESTRUTURADA

Objetivo da entrevista: explorar as potencialidades abertas pelo conceito de Smart City: discussão do conceito- o que é uma smart city e o que deve ser? e avaliação do caminho percorrido no sentido de tornar Guimarães uma cidade inteligente.

QUESTÕES

1) As cidades inteligentes têm sido definidas muito com base na tecnologia que permite a conexão nomeadamente entre os munícipes e diversas entidades (município, centro de saúde, instituições educativas...). Na sua opinião qual é o grande objetivo de uma cidade inteligente?

2) Neste domínio, com que cidades europeias considera Guimarães comparável? Ou ainda, que cidades europeias (ou não europeias) podem ser usadas como orientação para o desenvolvimento de Guimarães como cidade inteligente?

3) Na sua opinião qual a importância e o interesse em Guimarães desenvolver um caminho para se tornar uma cidade cada vez mais inteligente?

4) Como avalia o caminho já percorrido por Guimarães no sentido de se tornar uma cidade cada vez mais inteligente?

5) Na sua opinião, tendo em conta as recentes medidas tomadas, por exemplo, ao nível da separação do lixo orgânico e comum, e, das que se preveem para breve ao nível da eficiência energética, nomeadamente, a obtenção de 100% da iluminação pública feita através de luminárias LED, como perspetiva, isto é, como espera que seja o crescimento de Guimarães para se tornar uma cidade cada vez mais inteligente? O que falta? Que oportunidades de melhoria existem?

6) Como avalia o crescimento já atingido por Guimarães como cidade inteligente quando comparada com outras cidades de dimensão e características semelhantes, nomeadamente tomando por base as realizações efetuadas no ano de 2023?

7) Como são tomadas as decisões no que toca às prioridades no desenvolvimento de Guimarães a este nível? Analisam-se estudos internacionais, desenvolvem-se estudos regionais? Recorre-se a peritos na área ou utilizam-se as competências existentes na Câmara Municipal nomeadamente no pelouro do Planeamento Urbano?

8) Quais as áreas a que considera que deve ser dada prioridade, em Guimarães, no domínio da cidade inteligente?

9) Quando contrapomos a cidade e o resto do concelho a que áreas daria prioridade no sentido do crescimento sustentável.

CARACTERIZAÇÃO DOS ENTREVISTADOS

- idade:
- género:
- formação académica mais elevada:
- número de anos a trabalhar/lidar com questões relacionadas com o urbanismo e/ou as cidades inteligentes:
    - Fora de Guimarães:
    - Em Guimarães:
- qual é atualmente o seu papel (tarefas, responsabilidades) no domínio do planeamento urbanístico com vista ao desenvolvimento inteligente de Guimarães.

Appendix 3 – Questionnaire

Portuguese version:

Guimarães cidade inteligente - perspetiva dos cidadãos

Este questionário tem por objetivo descobrir como é que Guimarães está a responder ao desafio de se
tornar uma cidade inteligente, nomeadamente, saber se as pessoas que lá residem, estudam ou trabalham se revêem nas ações tomadas pelos responsáveis pelo planeamento urbano. Insere-se no âmbito de uma dissertação no Mestrado em Riscos, Cidades e Ordenamento do Território da Faculdade de Letras da Universidade do Porto.
O tempo de preenchimento não ultrapassa os 2 minutos
Agradece-se o seu preenchimento com sinceridade.

* Indicates required question

1. Concorda com a recolha de dados para analisar e extrair conclusões para fins de investigação? *

Mark only one oval.

- ◯ Sim
- ◯ Não *Skip to section 5 (Obrigado pela sua colaboração!)*

Skip to question 2

Filtragem da amostra

2. Reside ou trabalha/estuda no concelho de Guimarães? *

Mark only one oval.

- ◯ Sim
- ◯ Não *Skip to section 5 (Obrigado pela sua colaboração!)*

Dados pessoais

6. Grau académico mais elevado *

Mark only one oval.

- 1.º Ciclo
- 2.º Ciclo
- 3.º Ciclo
- ensino secundário
- bacharelato/licenciatura
- mestrado
- doutoramento

7. Estado civil *

Mark only one oval.

- Solteiro(a)
- Casado(a)
- União de facto
- Divorciado(a)/Viúvo(a)

Skip to question 8

Perceções dos munícipes

3. Género *

Mark only one oval.

- Feminino
- Masculino
- Prefiro não dizer

4. Idade *

Mark only one oval.

- 18-29
- 30-39
- 40-49
- 50-59
- 60 ou mais

5. Ocupação *

Mark only one oval.

- Estudante
- Estudante-trabalhador
- Trabalhador(a) por conta própria
- Trabalhador(a) por conta de outrém
- Reformado(a)
- Desempregado(a)
- Outra

8. Classifique de 1 (muito pouco importante) até 5 (muito importante) a importância que atribui a cada uma das seguintes categorias usadas para a classificação de uma cidade inteligente: *

Mark only one oval per row.

	1	2	3	4	5
Conetividade: a infraestrutura de rede e a cobertura de Internet de alta velocidade na cidade e concelho.	◯	◯	◯	◯	◯
Mobilidade inteligente: sistemas de transporte inteligentes, como transporte público elétrico, sistemas de compartilhamento de bicicletas e carros elétricos e trotinetes elétricas, soluções de gestão de tráfego para reduzir congestionamentos, gestão integrada de estacionamento, ...	◯	◯	◯	◯	◯
Eficiência energética: tecnologias e práticas para melhoria da eficiência energética dos edifícios públicos e privados, promovendo o uso de energias renováveis e a gestão inteligente de energia.	◯	◯	◯	◯	◯
Participação cidadãos: participação ativa	◯	◯	◯	◯	◯

no planeamento e na tomada de decisões, utilizando ferramentas digitais e plataformas de participação online.					
Gestão de resíduos: sistemas de gestão de resíduos inteligentes, como contentores de lixo inteligentes e programas de reciclagem mais eficazes.					
Saúde e bem-estar: soluções de saúde digital, como telemedicina e monitoramento de saúde, para melhoria do acesso aos cuidados de saúde e promoção de vida saudável.					
Educação digital: Integração da tecnologia na educação, com acesso a dispositivos e recursos digitais para estudantes e professores.					
Segurança: sistemas de segurança inteligente, como vigilância por vídeo e análise de dados.					
Turismo inteligente: uso de tecnologia para melhorar a experiência dos turistas, oferecendo informações em tempo real, guias					

virtuais e aplicativos de turismo.

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9. Classifique de 1 (muito pouco importante) até 5 (muito importante) a importância que, na sua opinião, **a Câmara Municipal de Guimarães atribui** às seguintes categorias: *

Mark only one oval per row.

	1	2	3	4	5
Conetividade: a infraestrutura de rede e a cobertura de Internet de alta velocidade na cidade e concelho.	◯	◯	◯	◯	◯
Mobilidade inteligente: sistemas de transporte inteligentes, como transporte público elétrico, sistemas de compartilhamento de bicicletas e carros elétricos e trotinetes elétricas, soluções de gestão de tráfego para reduzir congestionamentos, gestão integrada de estacionamento, ...	◯	◯	◯	◯	◯
Eficiência energética: tecnologias e práticas para melhoria da eficiência energética dos edifícios públicos e privados, promovendo o uso de energias renováveis e a gestão inteligente de energia.	◯	◯	◯	◯	◯
Participação cidadãos: participação ativa	◯	◯	◯	◯	◯

no planeamento e na tomada de decisões, utilizando ferramentas digitais e plataformas de participação online.					
Gestão de resíduos: sistemas de gestão de resíduos inteligentes, como contentores de lixo inteligentes e programas de reciclagem mais eficazes.	☐	☐	☐	☐	☐
Saúde e bem-estar: soluções de saúde digital, como telemedicina e monitoramento de saúde, para melhoria do acesso aos cuidados de saúde e promoção de vida saudável.	☐	☐	☐	☐	☐
Educação digital: Integração da tecnologia na educação, com acesso a dispositivos e recursos digitais para estudantes e professores.	☐	☐	☐	☐	☐
Segurança: sistemas de segurança inteligente, como vigilância por vídeo e análise de dados.	☐	☐	☐	☐	☐
Turismo inteligente: uso de tecnologia para melhorar a experiência dos turistas, oferecendo informações em tempo real, guias	☐	☐	☐	☐	☐

virtuais e aplicativos de turismo.

10. Como classifica a evolução da cidade de Guimarães no sentido de se tornar uma cidade inteligente *

Mark only one oval.

	1	2	3	4	5	
muit	◯	◯	◯	◯	◯	muito conseguida

11. Tendo por base a evolução da cidade de Guimarães para se tornar uma cidade inteligente, pode usar o espaço que se segue para sugestões e/ou contributos.

Skip to section 5 (Obrigado pela sua colaboração!)

Obrigado pela sua colaboração!