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DEVELOPMENT OF A FRAMEWORK AND INTERACTIVE DASHBOARD FOR EVALUATION AND MONITORING SMART REGIONS - THE OESTE SMART REGION CASE

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DEVELOPMENT OF A FRAMEWORK AND INTERACTIVE DASHBOARD FOR EVALUATION AND MONITORING SMART REGIONS - THE OESTE SMART REGION CASE

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DECLARATION OF ORIGINALITY

I declare that the work described in this document is my own and not from someone else. All the assistance I have received from other people is duly acknowledged and all the sources (published or not published) are referenced.

This work has not been previously evaluated or submitted to NOVA Information Management School or elsewhere.

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DEVELOPMENT OF A FRAMEWORK AND INTERACTIVE DASHBOARD FOR EVALUATION AND MONITORING SMART REGIONS - THE OESTE SMART REGION CASE

ABSTRACT

The 12 municipalities comprising the Oeste region of Portugal is desirous of developing a smart region. There is a need for the development of a framework and tool for the monitoring and evaluation of the performance of the Oeste smart region. These would also serve as a baseline against which progress could be measured. The goal of this thesis is, therefore, to develop and implement of a framework for the monitoring and evaluation of the performance of the Oeste smart region.

The study adopted a design research approach. It achieved its aim by reviewing literature and frameworks on smart regions and smart cities and noted four (4) dimensions and eighteen (18) indicators which were most important within the context of smart regions. These dimensions and indicators were then applied to the Oeste smart region context. Of the 18 indicators, fourteen (14) were available either directly or in form of proxy data, for the region. These 14 indicators in 4 dimensions were then used to construct an interactive dashboard. After the extract, transform and load (ETL), the storage, the dashboard construction, and data visualization were all performed in github to ensure reproducibility.

From the data presented, it was noted that the smartest municipality in the region is Nazaré, while the least is Cadaval. The dashboard was also used as a tool for smart region goal setting. This was demonstrated by setting a goal of a 10% increase in performance. The implications of setting a 10% increase in smartness were then presented at the regional, and municipality levels. Also, the targets for the indicators and dimensions were presented. Overall, the dashboard was effective as a tool for monitoring and evaluation of the smart region.

RESUMO

Os 12 municípios que compõem a região Oeste de Portugal desejam desenvolver uma região inteligente. Existe a necessidade do desenvolvimento de um framework e ferramenta para o monitoramento e avaliação do desempenho da região inteligente do Oeste. Estes também serviriam como uma linha de base contra a qual o progresso poderia ser medido. O objetivo desta tese é, portanto, desenvolver e implementar um framework para a monitorização e avaliação do desempenho da região inteligente do Oeste.

O estudo adotou uma abordagem de pesquisa de design. Ele alcançou seu objetivo revisando a literatura e estruturas sobre regiões inteligentes e cidades inteligentes e observou quatro (4) dimensões e dezoito (18) indicadores que eram mais importantes no contexto das regiões inteligentes. Estas dimensões e indicadores foram então aplicados ao contexto da região inteligente do Oeste. Dos 18 indicadores, quatorze (14) estavam disponíveis diretamente ou na forma de dados proxy para a região. Esses 14 indicadores em 4 dimensões foram então usados para construir um painel interativo. Após a extração, transformação e carregamento (ETL), o armazenamento, a construção do dashboard e a visualização dos dados foram todos realizados no github para garantir a reprodutibilidade.

A partir dos dados apresentados, notou-se que o município mais inteligente da região é a Nazaré, enquanto o menos é o Cadaval. O painel também foi usado como ferramenta para definição de metas de regiões inteligentes. Isso foi demonstrado ao estabelecer uma meta de 10% de aumento no desempenho. As implicações de definir um aumento de 10% na inteligência foram então apresentadas nos níveis regional e municipal. Também foram apresentadas as metas para os indicadores e dimensões. No geral, o dashboard foi eficaz como ferramenta de monitoramento e avaliação da região inteligente.

KEYWORDS

Smart city, Smart Region, Smart region framework, Dashboard, Dimensions, Indicators

PALAVRAS-CHAVE

Cidade inteligente, região inteligente, estrutura de região inteligente, painel, dimensões, indicadores

INDEX OF THE TEXT Pág.

INDEX OF TABLES

INDEX OF FIGURES

1 INTRODUCTION

Increasingly, the importance of developing Smart Regions is being recognized as a viable alternative to Smart Cities. A Smart Region is a territory comprising multiple smaller contiguous territories which together use information communication technology to procure improved quality of life for their residents while striving for environmental and economic sustainability. This concept holds potential for providing solutions to the twin criticisms of “an excessively technocratic and market-oriented approach to city management and planning and of an increasing social segregation in city use” (Morandi et al 2016) against the smart city concept. The increase in acceptance of the Smart Regions concept, however, throws up the need for the development of a workable framework for their monitoring and evaluation. In this context, monitoring refers to a process of tracking progress made towards the achievement of a goal or to guide its management decisions, while evaluation is the determination of impact or effectiveness an action or interventionist project has in the direction of a set goal.

The goal of this thesis is to design a framework for the monitoring and evaluation of smart regions. The importance of such a framework can be identified as first to provide the opportunity to demonstrate that project activity aimed at developing the smart region is having a measurable impact on expected outcomes. It is important to be able to relate individual projects activities to outcomes, that is, identifying how best project activities are linked to expected effects. This framework can therefore be said to be a tool for identifying, documenting, and tracking progress towards a set goal. Also, a framework for monitoring and evaluation is important to provide the necessary data required to guide strategic planning, design, and implementation of projects, and to better allocate, or re-allocate resources. The data generated within the framework will ensure that decisions on how to progress are evidence-based and not haphazard or uninformed. It, therefore, helps to ensure the most valuable and efficient use of resources is made.

Using relevant current literature on the development of smart cities, regions, and territories, dimensions and key indicators which prove to be of importance were determined. Available data on the Oeste region for these dimensions and indicators were then collected, synthesized, and developed into an interactive dashboard which can be used first as a tool to present a baseline study for the region before the commencement of the Smart Region project as well as to monitor and evaluate progress made during implementation.

This thesis is presented in five (5) chapters, this introductory chapter concludes by delineating the extent of the study area and stating the aim and objectives of this thesis. The succeeding chapter provides a backdrop for the study in the form of a literature review. The third chapter presents the methodology for the study while the fourth and fifth chapters contain the results of the study and the conclusion respectively.

The study area for this project is the Intermunicipal Community of Oeste (Comunidade Intermunicipal do Oeste: Oeste CIM) the municipalities within this region are collaborating to develop into a smart region. The region is comprised of twelve (12) municipalities these are Alcobaça, Alenquer, Arruda dos Vinhos, Bombarral, Cadaval, Caldas da Rainha, Lourinhã, Nazaré, Óbidos, Peniche, Sobral de Monte Agraço, Torres Vedras. It is expected that the development would significantly impact both the quality and quantity of infrastructure in the region. Therefore, there is a need for the development of a framework for the project which would both present a baseline study of the region as well as a tool for measuring progress made. Fig 1.1 and Fig 1.2 present the map showing the location of the Oeste Region and the constituent municipalities.

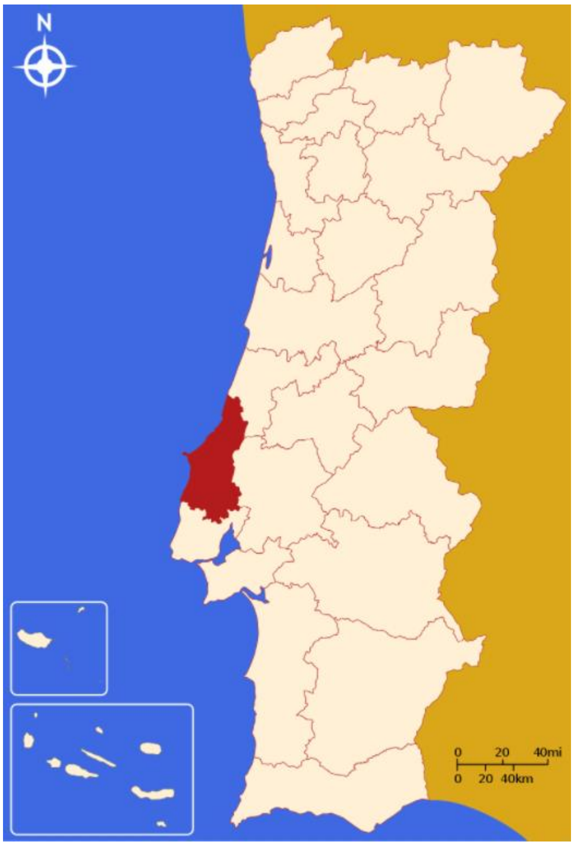

Fig 1.1: Location of Oeste Region

Source: Gazilion - Own work, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=64084708

Fig 1.2: Map of Constituent Municipalities of Oeste Region

1.2 AIM AND OBJECTIVES

AIM

To develop a framework and interactive dashboard for the monitoring and evaluation of the progress of the Oeste Smart Region project.

OBJECTIVES

1. Identify and select important dimensions to be monitored in the development of smart regions.

2 Identify and select key indicators for measuring smart regions.

3 Develop an interactive dashboard using selected indicators and dimensions to present progress in the smart region

2 LITERATURE REVIEW

2.1 CITIES, GLOBAL TRENDS, AND CHALLENGES OF URBANIZATION

To grasp the need for smart regional development, it is important to first understand the concept of, and problems with, cities and smart city development. The definition of a city is a fluid one. This is because various definitions have been provided, and it has been perceived in different ways. There is the demographic approach to its definition which varies in both space and time. For example, in countries like Denmark and Iceland with low national populations, the threshold used to define a city status is a population equal to or more than 200 inhabitants, while in the Netherlands and Nigeria it is put at 20,000, it is 30,000 in Mali and 50,000 people is the benchmark in Japan. There is also the economic and political approach to defining cities. While the economic point of view is based on the level of economic activity taking place within the settlement, primary, secondary, or tertiary, the political is founded on the administrative role the community plays in the context of its region for example Local Government headquarters or state capitals are usually defined as cities irrespective of their population. (UN-Habitat, 2020 and Smith & Lobo, 2019).

Whichever point of view is adopted for defining a city, evidence shows that increasingly more people are living in cities than before (Zhang, 2015). The percentage of the world's population living in cities was estimated at 30% in 1950, 50% in 2007 and it is expected to raise to 72% in 2050. (Zhang, 2015). The centripetal forces attracting people to cities include better economic opportunities, whether real or perceived, superior infrastructure, industrialization, commercialization, social services, natural increase, employment opportunities (Bodo, 2019, Cobbinah et al, 2015). Although there are advantages to urbanization and the concentration of people in cities, the phenomenon is not without its problems.

The major drawbacks associated with city development are the problems of large ecological footprints of cities, global warming, and climate change (McCarney et al 2011, McCarthy et al, 2010). Human activities in the city, are having large repercussions in places far beyond the location of the activities. The demand for resources in the city exerts pressure on available resources in the surrounding rural areas. Also, Cities are centers of high demand for transportation. The use of fossil fuels for transportation and other activities coupled with the inefficient modes of transportation is a leading source of CO_2 emission which is a major cause of global warming. A direct consequence of global warming is climate change. Climate change is a permanent change in the global weather pattern over a long period. At the heart of these problems appears to be the city, the nucleus of human activities.

2.1.1 Sustainable Development Goals

The sustainable development goals (SDGs) are a set of 17 goals, 169 targets, and 232 indicators that will form the development agenda for the General Assembly of the United Nations (UN) between the years 2015 and 2030. To address the problems of cities earlier discussed, world leaders have included in the SDGs four (4) urbanization-related goals. These goals, which are directly aimed at addressing the urbanization problems, are goal 11, achieving sustainable cities and communities, goal 12, responsible consumption and production, and goal 13 climate action.

Examples of the targets of these goals to be achieved by 2030 include "Empower and promote the social, economic, and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status" (target 10.2), "Enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.", (target 11.2). "Provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons",(target 11.3). "Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning" (target 13.3). it is important to note that these targets can benefit from continuous and efficient data collection, efficient transmission of data, data security, capabilities of information and communication technology (ICT). The application of ICT to the achievement of these targets has therefore been advocated by Tjoa and Tjoa (2016), Janowski (2016), and Chien et al. (2021). This application implies the need for an increase in city smartness.

2.1.2 Smart Cities

A smart city is one " with high capacity of learning and innovation, which is built on its digital infrastructure and promotes strategy for development that will improve the quality of life of its residents"(Mazza & Mavri, 2019). In searching for the meaning of a smart city, Winkowska et al.(2019) noted the alternative terms for the concept as: "digital city", "wired city", "information city", "ubiquitous city", and "sensing city". Overall, it is a human settlement system that has achieved partial or total efficiency in the running of its various subsystems e.g., transport, governance, security, etc by using data to make fast and intelligent decisions. It is where information and communication technologies are used to maintain livability, workability, and sustainability (Tunç |, n.d.). It can be concluded that a smart city uses ICT to improve operational efficiency, share information with the public and provide a better quality of government service and citizen welfare.

Tunç |, n.d. identified 3 aspects of a smart city as “, collecting, communicating and crunching” explained as data collection through sensors and other means, communicate the collected information via wired or wireless networks and the analysis of the information to make sense of it to improve the city systems. (Mazza & Mavri, 2019)), further recognized six (6) core domains as Governance, Economic, People, Technology, Infrastructure and Environment as the pillars of a smart city. (Bauer et al., 2019) emphasized that at the heart of a smart city is not technology but humans and the betterment of the quality of life. The smart city has however been criticized as being an excessively technocratic and market-oriented approach to city management and planning and it encourages social segregation in city use” (Morandi et al 2016), hence the development of the concept of smart regions.

2.1.3 Regions and Smart Regions

Smart regions are conceptualized as a panacea to the identified criticism of smart cities. Although there is no agreed definition of what a region is (Vukovic & Kochetkov, 2017), Matern et al. (2020) argued that it is important to first comprehend what a region is before studying what smart regions are. The problem of the definition of a region is associated with its multifaceted nature (Vukovic & Kochetkov, 2017). An early definition by Hartshorne (1959) opined that it is ‘an area of specific location which is in some way distinctive from other areas, and which extends as far as that distinction extends’. It was also referred to as a ‘cohesive area that is homogeneous in selected defining criteria and is distinguished from neighbouring areas or regions by those criteria’. by the Encyclopedia Britannica. Mazza & Mavri, (2019) captured the essence of a region relevant to this study as “an association of regions or cities with different growth rates, with different spatial development and physical - technological infrastructure and with different needs of citizens”.

On the other hand, the term smart region is synonymous with the smart territory, intelligent territory, and smart area. It is described as a tool for achieving sustainable planning at the regional level by promoting knowledge-based development through the continuous learning of human resources as an integrative part of regional resource development (Sutriadi, 2018). Kodym & Unucka, (2017) viewed it simply as a region that employs modern technology to save time and money for people who live within it and Bauer et al.(2019) understood the concept as a region that solves tasks and challenges by wisely applying new technologies, by organizing processes or by making wise, future-proof decisions. The common thread in all the definitions is the fact that smart regions adopt various ICT technologies to achieve an improved quality of life and environment.

Available information about smart regions is largely shaped by debates on smart cities and current research on smart regions is strongly influenced by an economic perspective with an emphasis on growth, innovation, and policy strategies (Matern et al. 2020). This agrees with Shearmur et al. (2017) who also emphasized that smart regions are 'the result of the dynamics in different economic sectors.' Therefore, a smart region is a territory comprising multiple smaller contiguous territories which together build smart systems to procure improved quality of life for their residents while striving for environmental and economic sustainability.

2.2 RATIONALE FOR THE DEVELOPMENT OF SMART REGIONS

The EU Horizon2020 Agenda is that Smart Cities will be hugely dependent on and inter-connected with their regional hinterlands (Tunç |, n.d.), cities can no longer be pictured as isolated entities (Amin & Thrift, 2002). The rationale for the emphasis on the development of smart regions is discussed in the following sections.

Boorsma et al. (2018) identified five (5) compelling reasons for the development of smart regions these are digital inclusion, Collaboration and Economy of Scale, Effective Public-Private Collaboration, City Limits are Not Data Limits, Improve Capacity to Provide Service to Small Communities.

2.2.1 Digital Inclusion

The creation of smart regions would bridge the digital divide between cities and their regions. While cities have benefited from the innovations which come with smart technology, for example in the areas of resilience and sustainability, improved public security, mobility, and 21st-century jobs, their surrounding smaller communities, usually poorer, are left behind. Smart regions would ensure that these benefits are made available to rural communities. This would also help in achieving the 8^{th} goal of the SDGs which states is 'Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all'.

2.2.2 Collaboration and Economy of Scale

The collaboration that is forged by the creation of smart regions would provide the benefit of economy of scale. Cities have the advantage of being wealthier attracting more research and innovation and can articulate and implement smart strategies. The smart region would enable large cities and smaller communities to share know-how and resource and small communities would not have to single-handedly fund large research, innovation, and digitalization programs but they can tap from their larger richer cities. Also, digitalization requires the procurement of very expensive technologies. The economy of scale of smart regions is seen when joint procurement schemes are made and compared to individual communities making procurement.

2.2.3 Effective Public-Private Collaboration

Boorsma et al. (2018) distinguished between traditional public-private partnerships and effective public-private partnerships. While the former may ‘represent an ineffective approach when managing dynamic innovation agendas’, an effective public-private partnership requires each partner holds the others accountable. Large non-fragmented regional collaboration provides a better environment for accountability both among municipalities and between public and private sectors. Also, investing at a regional scale and having a much larger market would be a more attractive incentive to the private sector innovators who want to sell their products and are always searching for a larger market share.

2.2.4 City Limits are Not Data Limits

Many innovations such as smart mobility, automated vehicles, and smart power distribution require the joint creation of standards, regulations, and experimentation. These innovations would be less efficient if they only provide service at the city scale leaving out the surrounding region. Without standards applied to a wider scale, like the region, smart mobility operations in one municipality would not function effectively in a neighboring municipality. Collaboration at the regional scale in defining standards and regulations ensures interoperability.

2.2.5 Improve Capacity to Provide Service to Small Communities

Small communities are limited in know-how, have rudimentary infrastructures, and limited funds but since many smart capabilities are data and cloud-driven services, such as smart parking and outdoor lighting, can be extended to rural communities as services.

Other benefits of pursuing smart regions are its potential to establish equilibrium between rural and urban populations and slow rural-urban negative demographic trend (Bauer et al., 2019)

2.3 THREE CASE STUDIES OF SMART REGIONS

Case studies of current efforts to develop smart regions are discussed in this section. These case studies were selected based on their relative availability of information and the fact that there is documentation of some projects that have been implemented in these smart regions. Because the concept of smart regions is still relatively novel, the dearth of information about the implementation of smart regions poses a limitation. The three cases are the Greater Phoenix Smart Region, the Flanders Smart Region, and the Brescia Smart Area projects.

2.3.1 Greater Phoenix region – The Connective

The Greater Phoenix smart region project also named the connective project involves an agglomeration of 33 municipalities within three counties covering 17,000 square miles of land in the United States of America. The region has a large and rapidly growing population, with its associated problems and is expected to experience droughts, heat waves, and flooding resulting from climate change.

As a response to these problems, the connective project was launched. The central goals of the project are to improve quality of life, Drive equity, enhance revenue, promote sustainability and resilience, and support economic competitiveness. It leverages technologies that are rooted in connectivity, mobility, equity, and sustainability to create a smart region that works for its residents. To achieve these goals, the region is committed to efforts to regional collaboration, best practices sharing, competency framework, research and data analysis, validation, and testing, and implementing solutions at scale. These efforts are summarized as research, development, and deployment.

The project involves the partnership of, academia, industry, and civic institutions in the areas of applied research and implementation the main partnering bodies being Arizona State University. the Greater Phoenix Economic Council (GPEC). Maricopa Association of Governments, the Partnership for Economic Innovation, and the Institute for Digital Progress. The role of these bodies is to create a reputation of Greater Phoenix as a foremost location on the globe where companies can test, develop, and deploy technology at scale. This is done while providing residents with a technologically advanced lifestyle.

2.3.2 Flanders Smart Region, Belgium- VLOCA

The Flanders region, in Belgium, encompasses 28 municipalities with numerous medium-sized cities which are each less than 1 million people but have many isolated investments in smart technologies. The idea of a Flanders Smart Region was borne out of the need to harmonize the different islands of innovation into a single region with common standards for digitalization data exchange infrastructure called the new Flanders Open City Architecture (VLOCA).

The VLOCA is to develop solutions for gathering, processing, and converting data into useful information for policymakers. These solutions and their sharing among the composing territories will ensure that there is no repletion of efforts by the municipalities in research. These VLOCA solutions are designed to be a broad-based reference framework for projects at the various levels i.e., smart cities, municipalities, and the Flemish region, and are products of cocreation processes. The first step in the process involves the getting of buy-in of the participating local government, research institutions, businesses, and IT providers needed to develop a customized design for the region.

One smart framework-dimensions where VLOCA has developed a smart solution is in the monitoring of water quality. The IoW Flanders consortium is a collaboration of imec, VITO, Flanders Knowledge Center Water (VLAKWA), Flanders Environment Agency (VMM), De Watergroep, and Aquafin, with the support of Flanders Innovation and Entrepreneurship (VLAIO. Its goal is to develop a scalable IoT stack to disclose sensor data for water in a uniform way. They are concerned with the process of setting technologies, data standards, and applications, as well as all the communication steps in between. This means that standards are developed for the entire system from the sensors used to collect water quality data in the pond to the transmission of structured data via the internet to a database and context broker (i.e., data standards and IT technology) to the processing of the data to obtain relevant information.

The first step was in the development of the data architecture is contextual data should be collected alongside the measurement data itself. Examples of context, in this case, include the context in which the data are being captured (e.g., weather conditions) as well as the status of the sensor (e.g. battery power, time of installation, position, quality of the wireless link…). This contextual information is important to allow the comparison and combination of data that comes from the various types of sensors to the IoT stack are compatible. The second step is to ensure scalability of the IoT stack that is, how to link all the sensors to one data bank and connect it to a control/dashboard functionality to keep track of the status of these sensors and the quality of their network connections and data streams. IoW Flanders uses self-learning algorithms and hydrological models to process all relevant data and translate them into information that is useful for policy making.

The data is transmitted from sensor to imec OCTA platform (low power transmission of data collected by sensors) to cloud (private and commercial public clouds) In the private cloud, the stack connects to the data servers of IDLab, an imec research group at Ghent University. Along with the whole IoW system, the Euro commission MIM - Minimal Interoperability Mechanism was used as standard so that the solution also complies with the internationally agreed minimal interoperability requirements.

2.3.3 Brescia - Smart Area BS

The Brescia Smart Area is composed of 28 contiguous municipalities in northern Italy. The area is comprised of the city of Brescia, a flourishing and sprawling urban center, and its rural surroundings poorer communities upon which the city feeds. The goal of the region is therefore to promote innovative instruments and services for encouraging the growth of businesses, services for the citizen, the care and monitoring of the environment, the dialogue between administrations and users.

This goal is pursued by the implementation, creation, and management of broad and narrow band connectivity networks to support the development of smart services in the areas, the interconnection of people, objects in a unified manner on the entire network of participating municipalities. The broad and narrow band connectivity networks are expected to be catalysts for participating territorial authorities to develop solutions to problems unique to them, ranging from environmental monitoring, intrusion detection security, the structural monitoring of the territory, smart building comfort, intelligent irrigation, and smart waste baskets.

In pursuit of the provision of this infrastructure, already proposed services, traditional and innovative, broadband and narrow band include the installation of 165 “Gateways” for the implementation of the radio frequency coverage and enable smart services, the installation of 208 new access point and the gradual replacement of 200 currently installed access points to improve the quality and the coverage of the Wi-Fi service and installation of intrusion detection, environmental and building comfort sensors and for structural monitoring. Also proposed is the software application that will make the data collected usable.

The Table 2.2 compares the three (3) smart regions of Brecia, Landers, and Greater phoenix region. It is noteworthy that the three cases adopted 3 different strategies in “smartening” their regions. While Brescia focused on the provision of broad and narrow band connectivity networks, the Flanders region strategy is to provide open data on the activities of each component of the region so that there is freedom of information and synergy among members. The Greater phoenix region concentrated on the creation of fertile environment for the testing of innovative ideas. Another notable difference among the cases studies are the primary drivers of the smart region projects. This ranges from government institutions to private firms and university institutes.

NAME	PROVINCE OF BRESCIA	FLANDERS, BELGIUM	GREATER PHOENIX REGION
Size	28 Municipalities	13 cities	33 municipalities, 3 counties
Strategy	Provide and manage broad and narrow band connectivity networks to support the development of smart services in the areas. To stimulate unique smartness in each municipality's vision.	Common Open data policy and data exchange infrastructure to standardize operations of participants	Create an environment where the region becomes the most attractive place for private-sector innovators to test innovation. By so doing, provide a 21st-century lifestyle for residents.
Example of Smart constituents implemented	smart governance and capacity building	IoW water quality monitoring	Mobility (self-driving cars)
Primary Drivers	Province of Brescia	Imec and VITO	Institute of Digital Progress (IDP) of ASU
Secondary Drivers	A2A Smart City	Municipalities govt	3 counties, Uber, Intel, Cisco, and Arizona State University
Achievements	installation of 165 "Gateways" 208 new Access Point	Commencement of monitoring of water quality	Won multi-million-dollar Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)

Table 2.1: Summary of Reviewed Smart Regions

2.4 IMPACT OF AI, BIG DATA, IOT SENSOR TECHNOLOGY, AND TECHNOLOGICAL CONNECTIVITY

AI, Big Data, IoT, and Sensor Tech are the building blocks upon which the dimensions of a smart region would be built. This section discusses the potential impact of the adoption of AI, Big Data, Sensor technology on human settlement

Literature is replete with studies about the potential and current impact of new technologies such as AI, IoT Big Data, etc. The impact of these technologies is expected to be all-pervading and be drastic. In an important area of healthcare provision, it is for example expected to provide more efficient systems of organ donation, better access to quality medical care, larger medical data upon which health decisions can be made (Chattopadhyay & Majumdar, 2020; Ferreira et al., 2020; Kumar et al., 2019). In the area of public transport, it has the potential to achieve cheaper, more efficient and cleaner public transport. (Attaran, 2017; Ferreira et al., 2020; Kumar et al., 2019), the use of sensor technology in infrastructure provision also holds the promise of efficiency, monitoring, and ease of maintenance (Hossein Motlagh et al., 2020). Agriculture and food production is not left out in the possible application of these modern technologies as their application is expected to yield better cheaper and eco-friendly crops (Aggarwal & Singh, 2021). The application areas, as well as the impact of these technologies, also include Climate Change and disaster preparedness, improved work efficiency, customer services, financial services, and retail.

Overall, it is expected that these innovations in technology would have both positive socioeconomic implications as improved quality of life, better employment, higher incomes, greater access to education, improved community safety, and access to social support. On the other hand, possible negative impacts include some losses in manual jobs and privacy concerns

It could therefore be concluded that the application of AI and other disruptive technologies to human systems at the rural, urban or regional scales will significantly alter its social, economic, demographic, and infrastructure characteristics. Although these changes are expected in the study region, the extent, as well as the dimensions of these changes, are yet to be known. Therefore, there is a need to study the current infrastructure and socio-economic situation of the region and the interplay between these in other to provide a baseline for future impact assessment.

3 METHODOLOGIES

3.0 INTRODUCTION

The objectives of this thesis are to identify important dimensions to be monitored in the development of smart regions, identify key indicators for measuring smart regions, develop an interactive dashboard using selected indicators to present data for Oeste smart region. This chapter commences by presenting the procedure adopted for the development of the smart region framework. Then, it discusses the sources of the data used for the measurement of the indicators adopted for the study. It concludes with a description of the steps adopted to design the interactive dashboard.

3.1 DESIGN SCIENCE RESEARCH (DSR)

In this thesis, Design Science Research (DSR) methodology is used for the development of an interactive dashboard for the Oeste region. The choice of DSR is based on its relevance to the nature of the problem to be solved. The objective of this thesis is the creation of a solution for a problem, that is, the need for a tool for monitoring and evaluation of progress in the Oeste smart region. This objective aligns with the goal of design science research, which is, to develop a new reality, create a solution to a problem (Pello, 2018). DSR has been described as pursuing the enhancement of technology and scientific knowledge bases through the formation of innovative artifacts that solve problems and improve the environment in which they are instantiated (Vom, Hevner, Maedche 2020). Iivari and Venable (2009) define DSR as a "research activity that invents or builds new, innovative artifacts for solving problems or achieving improvements, i.e. DSR creates new a way for achieving a general goal, as its major research contributions. Such new and innovative artifacts create a new reality, rather than explaining existing reality or helping to make sense of it". Therefore, it can be viewed as a pattern for creative problem-solving. This is distinct from the goal of either explaining an existing reality or helping to make sense of it, as is in the cases of natural and human sciences (Iivari and Venable, 2009). This field of research looks to develop valid and reliable knowledge for designing solutions to problems and to use this knowledge to both solve problems and generate new knowledge insights. (Van Aken,2004, Horváth, 2007 and Baskerville et al., 2015).

Various attempts have been made to provide a scientific process for DSN. Vaishnavi and Kuechler (2004) and Peffers et al. (2007) are however agreed on what should constitute the Design Science Research Methodological Approach. The six (6) constituents as seen in Fig 3.1 are (1) the identification of the problem; (2) definition of objectives for a solution; (3) design and development of artifacts (4) demonstration; (5) evaluation of the solution; and (6) communication of the problem. Table 3.1 presents a list of activities, their description, and their application to the Oeste smart region project.

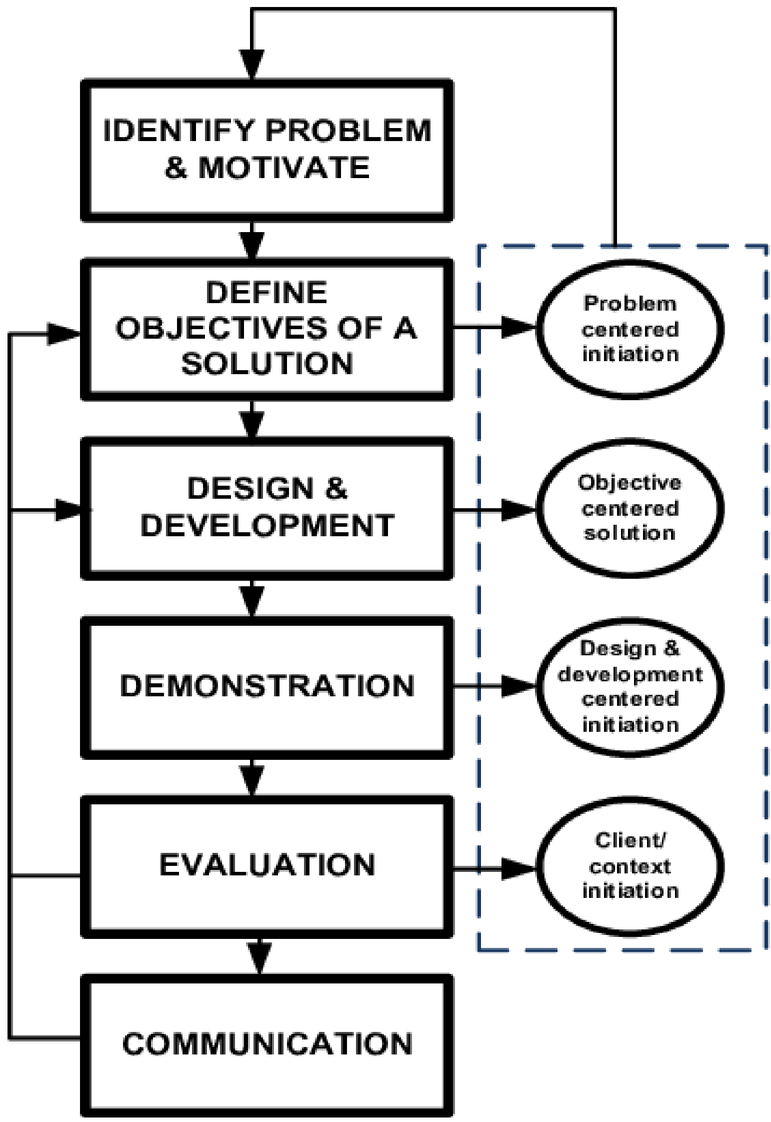

Fig 3.1: Design Science Research Methodological Approach Peffers et al. (2007)

Stages	Activity	Description	Application to Oeste Region
One	Problem identification and motivation	Define the specific research problem and justify the value of a solution	Develop a means of monitoring and evaluating Smart region progress for Oeste.
Two	Define the objectives for a solution	Infer the objectives of a solution from the problem definition and knowledge of what is possible and feasible	Systematically select relevant data for dimensions and indicators.
Three	Design and development	Determine the artifact's desired functionality and its architecture and then create the actual artifact	Based on selected indicators, create a data model which will determine how the different dimensions and indicators will relate and display on a dashboard.
Four	Demonstration	Demonstrate the use of the artifact to solve one or more instances of the problem	To be demonstrated To supervisors To be demonstrated at Oeste
Five	Evaluation	Observe and measure how well the artifact supports a solution to the problem	Get feedback from Supervisors Get feedback from Oeste
Six	Communication	Communicate the problem and its importance, the artifact, its utility and novelty, the rigor of the design, and its effectiveness to researchers and other relevant audiences.	Improve dashboard based on feedback received Write final report

Table 3.1: Adaptation of Peffers et al. (2007) Design Science Research Methodology to Oeste smart region.

From Table 3.1, stage one has been defined as the aim of this thesis in section 1.2 of the introductory chapter of this report. Stage 2 is discussed in section 3.2 in this methodology chapter. A discussion on data sources and transformation is in section 3.3 while the third stage is presented in section 3.4.

3.2 DEVELOPMENT OF FRAMEWORK

The development of the framework for the Oeste smart region was in two stages. These are the selection of dimensions to be measured and the selection of indicators for each dimension.

As noted earlier, Matern et al. (2020) opined that available information about smart regions is largely shaped by debates on smart cities. Therefore, to develop a framework for the evaluation of smart regions, it is useful to include discussions on how smart cities are evaluated. This enables the development of metrics for smart region monitoring and evaluation. This section discusses the dimensions, that have been suggested, for measuring smart cities and regions. It reviews the smart city dimensions identified by International Standards Organization (ISO). International Telecommunication Union (ITU), CITY keys, and smart region dimensions by Soe (2017), and Mazza & Mavri (2019).

The International Standards Organization (ISO) is an international nongovernmental organization involving an agglomeration standard regulatory body from all countries. The goal of the organization is to formulate and publish standards for various products, materials, and processes leading to the creation of minimum global standards. The standards developed cover proprietary, industrial, and commercial standards and have covered domains as healthcare technology, railway engineering, jewelry, clothing, metallurgy, weapons, paint, civil engineering, agriculture, and aircraft. The organization has produced ISO 37122 standard which provides standards for measuring Sustainable Smart cities and communities.

The ISO 37122 (2019) Sustainable smart cities and communities document defines a smart city as a “city that increases the pace at which it provides social, economic and environmental sustainability outcomes and responds to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how it engages society, applies collaborative leadership methods, works across disciplines and city systems, and uses data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors), now and for the foreseeable future, without the unfair disadvantage of others or degradation of the natural environment” and stipulates 18 dimensions and 80 indicators for assessing smart cities. The eighteen (18) ISO smart cities dimensions are Economy, Education, Energy, Environment and climate, Finance, Governance, Health, Housing, Recreation, Safety, Solid waste, Sports and culture, Telecommunication, Transportation, Urban/Local agriculture, Urban planning, Wastewater, and Water.

The International Telecommunication Union (ITU) is the United Nations specialized agency for information and communication technologies (ICT). Its goal is to facilitate international connectivity in communications networks. It allocates global radio spectrum and satellite orbits, develops the technical standards that ensure networks and technologies seamlessly interconnect, and strives to improve access to ICTs to underserved communities globally. The Organization’s activities are focused around three (3) areas these are radiocommunication, recommendation of standards, and development of telecommunication.

The ITU-T Y.4900 recommendation of the ITU defines a smart city as “A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, the efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations concerning economic, social, environmental as well as cultural aspects". It also identified 3 key dimensions and 91 indicators. The dimensions are Economy, environment, society, and culture.

The CITY keys project is an EU HORIZON 2020 funded program to develop and validated key performance indicators and data collection procedures for the common and transparent monitoring as well as the comparability of smart city solutions across European cities. The program is coordinated by research institutes VTT of Finland, AIT in Austria, and TNO in the Netherlands. These are in collaboration with five European cities – Rotterdam, Tampere, Vienna, Zagreb, and Zaragoza. Specifically, their activities are geared towards defining the needs, analyzing existing results, and developing recommendations for the use of performance indicators. Refer

The CITY keys project (2017) adopting the EU definition of a smart city described it as “a city seeking to address public issues via ICT-based solutions based on a multi-stakeholder, municipally based partnership. These solutions are developed and refined through Smart City initiatives, either as discrete projects or (more usually) as a network of overlapping activities.”. It also identified 4 dimensions and 18 indicators which are metrics for its evaluation. The five dimensions are people, planet, prosperity governance, and propagation.

Soe (2017), relaying on Boyd Cohen’s Smart Region Wheel, conceptualized a six (6) dimensioned framework for smart cities. These dimensions were identified as smart economy, smart governance, smart people, smart living, smart mobility, and smart environment. Each of these dimensions were provided with three (3) actions and indicators which would aid the achievement of the smart city.

Like Soe (2017), Mazza & Mavri (2019) proposed six (6) pillars of a smart region as e-governance, which is the adoption of ICT in the conduct of government activities, economics, that is, the embracing of ICT by industry and businesses in other to create new jobs. The third and fourth are people, referring to informed, educated, and participatory citizens. The fifth is technology, the investment in ICT infrastructure to enhance connectivity. Others are infrastructure, the availability of connected physical infrastructure such as power and water systems, building, etc., and the environment, the development of innovative technologies which ecofriendly.

3.2.1 Selection of Dimensions

To select the dimensions, a review of these five (5) frameworks for smart cities and smart regions was conducted. These were smart city frameworks developed by International Standards Organization (ISO). International Telecommunication Union (ITU), CITY keys, Cohens Smart city wheel in Soe (2017), and smart region framework by Mazza & Mavri (2019). From the reviewed literature, a total of twenty-one (21) dimensions were identified. A comparison was made among the reviewed literature and the number of times each dimension appeared was noted.

A count of each occurrence was then made to determine the frequency and by implication, the importance of each dimension. Table 3.1 presents the summary of the steps adopted in the dimension selection. Finally, the dimensions which scored a frequency of 3, out of 5, and above were considered important and therefore were included in the final selected list of dimensions to be adopted in the study. These were Economy and Prosperity (5), Environment, climate, and the Planet (5), Governance (4), and Society/ people (4).

DIMENSIONS	A	B	C	D	E	COUNT
Economy/ Prosperity	X	X	X	X	X	5
Environment, climate, and Planet	X	X	X	X	X	5
Governance	X		X	X	X	4
Society, Culture and People		X	X	X	X	4
Telecommunication/ Technology	X				X	2
Health	X			X		2
Transportation/ Mobility	X			X		2
Housing/ Mixed Landuse	X					2
Sports	X					2
Propagation			X			1
Education,	X					1
Energy	X					1
Finance	X					1
Infrastructure					X	1
Recreation	X					1
Safety	X					1
Solid waste	X					1
Urban/Local agriculture	X					1
Urban planning	X					1
Wastewater	X					1
Water	X					1

A= ISO 37122 (2019), B = ITU-T Y.4900 recommendation, C= CITY keys 2017, D= Soe (2017), E= Mazza & Mavri (2019)

Table 3.2: Comparison and Selection of Dimensions

A summary of the description of the four (4) selected dimensions describing indicators that could be used to measure them is discussed in detail, based on their ranking.

Economy and Prosperity: this refers to the impact of ICT on the economy of the region and its residents. It is meant to measure the degree to which smart ideas can thrive in the region. Creativity and innovation are drivers of smart regions and economies. This dimension can be measured by the number of companies and jobs available in the creative and innovative sector of the regional economy, the percentage of gross domestic product GDP invested in research and development, and export, import, and trade balance

Environment, climate, and the Planet: It is expected that improvement in ICT would also lead to improvement in the quality of the environment. The adoption of ICT in mobility and environmental monitoring for example is expected to reduce the impact of human activities on the natural environment. This can be measured in the quality of air, water, and soil. These are assessed by the amount of GHG in the air, hazardous chemical content in the water and soil, and the size of degraded land in sqm. The amount of open data and maps which measure both flora and fauna are also indicative of how sustainable the environment in the region is.

Governance: Smart governance refers to the degree of adoption of smart systems to provide government service and make public government data and expenditure. This can be measured using the degree of availability of open data, percentage of payments to government and administrative services that can be performed online as well as how well these services are used.

ICT is expected to impact the various way that government interact with the citizens as well as improve the access to government services

Society, Culture, and People: this dimension is a measure of the degree to which residents of smart regions have integrated ICT into their daily lives. it measures the digital inclusion of the residents. It can be measured by indicators as the number of digital devices connected to the internet and available to students at primary and secondary levels, degree of access to online learning platforms, and digital literacy. Integration of ICT into the daily lives of the resident is expected to increase safety, security while carrying out daily activities such as education, transportation, and shopping.

3.2.2 Selection of Indicators

To select the indicators for the framework, the indicators for the four (4) selected dimensions were compiled, tabulated, and compared to determine the number of occurrences of each indicator Tables 3.3 to Table 3.6. The indicators which occurred more than once were selected, these were a total of 18 indicators. These indicators are considered the proposed indicators for the Oeste smart region framework Table 3.7.

Then, this framework was then tested by evaluating each indicator to determine the availability of its data. If the data could be gotten, it is included in the final framework for Oeste smart region project. In the case where the exact data cannot be gotten, the indicator is evaluated to determine if a proxy can be sourced, if a proxy can be gotten, the indicator is also included in the final framework. Any indicator for which data cannot be gotten or a proxy cannot be gotten is excluded from the study.

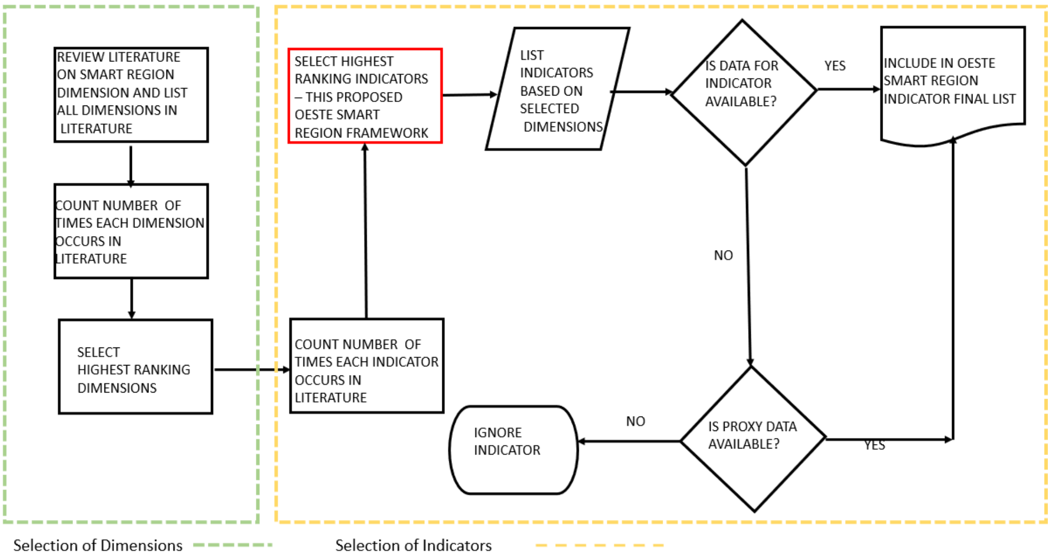

Fig 3.2 Selection Process for dimensions and Indicators

<table>
<tr><td rowspan="4">ISO/CD 37122 (A)</td><td>1</td><td colspan="3">Percentage of local businesses providing city services with data communication openly available</td></tr>
<tr><td>2</td><td colspan="3">Annual number of new start-ups per 100 000 population</td></tr>
<tr><td>3</td><td colspan="3">Percentage of labour force employed in the ICT sector</td></tr>
<tr><td>4</td><td colspan="3">Percentage of the labour force employed in the Education and Research & Development sectors</td></tr>
<tr><td rowspan="21">ITU (B)</td><td>1</td><td>Household Internet Access</td><td>23</td><td>Basic Water Supply</td></tr>
<tr><td>2</td><td>Fixed Broadband Subscriptions</td><td>24</td><td>Potable Water Supply</td></tr>
<tr><td>3</td><td>Wireless Broadband Subscriptions</td><td>25</td><td>Water Supply Loss</td></tr>
<tr><td>4</td><td>Wireless Broadband Coverage</td><td>26</td><td>Wastewater Collection</td></tr>
<tr><td>5</td><td>Availability of WIFI in Public Areas</td><td>27</td><td>Household Sanitation</td></tr>
<tr><td>6</td><td>Water Supply ICT Monitoring</td><td>28</td><td>Solid Waste Collection</td></tr>
<tr><td>7</td><td>Storm Water System with ICT Monitoring</td><td>29</td><td>Electricity System Outage Frequency</td></tr>
<tr><td>8</td><td>Smart Electricity Meters</td><td>30</td><td>Electricity System Outage Time</td></tr>
<tr><td>9</td><td>Electricity Supply ICT Monitoring</td><td>31</td><td>Access to Electricity</td></tr>
<tr><td>10</td><td>Demand Response Penetration</td><td>32</td><td>Public Transport Network</td></tr>
<tr><td>11</td><td>Dynamic Public Transport Information</td><td>33</td><td>Public Transport Network Convenience</td></tr>
<tr><td>12</td><td>Traffic Monitoring</td><td>34</td><td>Bicycle Network</td></tr>
<tr><td>13</td><td>Intersection Control</td><td>35</td><td>Shared Bicycles</td></tr>
<tr><td>14</td><td>e-Government</td><td>36</td><td>Shared Vehicles</td></tr>
<tr><td>15</td><td>Public Sector e-Procurement</td><td>37</td><td>Low-Carbon Emission Passenger Vehicles</td></tr>
<tr><td>16</td><td>R&D Expenditure</td><td>38</td><td>Public Building Sustainability</td></tr>
<tr><td>17</td><td>Patents</td><td>39</td><td>IBM Systems in Public Buildings</td></tr>
<tr><td>18</td><td>Small and Medium-Sized Enterprises</td><td>40</td><td>Pedestrian infrastructure</td></tr>
<tr><td>19</td><td>Unemployment Rate</td><td>41</td><td>Urban Development and Spatial Planning</td></tr>
<tr><td>20</td><td>Youth Unemployment Rate</td><td></td><td></td></tr>
<tr><td>21</td><td>Tourism Sector Employment</td><td></td><td></td></tr>
</table>

	22	ICT Sector Employment		
CITYkeys (C)	1	Percentage of the labor force unemployed		
	2	Percentage of youth labor force unemployed		
	3	The percentage of households unable to afford the most basic levels of energy		
	4	Percentage annual procurement using environmental criteria as a share of total annual procurement of the city administration		
	5	Share of companies based in the city holding an ISO 14001 certificate		
	6	% of the population living in affordable housing		
	7	Share of jobs related to environmental service activities that contribute substantially to preserving or restoring environmental quality		
	8	The number of freight vehicles moving into an area		
	9	City's gross domestic product per capita		
	10	Number of new businesses per 100,000 population		
	11	Median disposable annual household income		
	12	Share of people working in creative industries		
	13	# of innovation hubs in the city, whether private or public, per 100.000 inhabitants		
	14	The extent to which the open city data are easy to use		
	15	R&D expenditure as a percentage of the city's GDP		
	16	# of open government datasets per 100.000 inhabitants		
Soe (2017) (D)	1	Opportunity		
	2	Productivity		
	3	Local and Global interconnection		
Mazza & Mavri (2019) (E)	1	Trademarks	4	The flexibility of the labor market
	2	Innovation	5	Integration in the national and global market
	3	Productivity		

Matching colors indicate matching indicators

Table 3.3: Comparison of Indicators – Economy/Prosperity

ISO/CD 37122 (A)	1	Percentage of ecosystems that are mapped by remote sensing monitoring		
	2	Annual frequency of ecosystem remote sensing monitoring		
	3	Percentage of buildings built or refurbished within the last 5 years in conformity with green building principles		
	4	Number of real-time ICT-based air quality monitoring stations per 100 000 population		
ITU (B)	1	Air Pollution	9	Noise Exposure
	2	GHG Emissions	10	Green Areas
	3	Drinking-Water Quality	11	Green Area Accessibility
	4	Water Consumption	12	Recreational Facilities
	5	Freshwater Consumption	13	Renewable Energy Consumption
	6	Wastewater Treatment	14	Electricity Consumption
	7	Solid Waste Treatment	15	Residential Thermal Energy Consumption
	8	EMF Exposure	16	Public Building Energy Consumption
CITYkeys (C)	1	Percentage change in annual final energy consumption due to the project for all uses and forms of energy		
	2	Reduction in life cycle energy use achieved by the project (%)		

	3	Percentage increase in the share of local renewable energy due to the project		
	4	Percentage reduction in direct (operational) CO2 emissions achieved by the project		
	5	Percentage reduction in lifecycle CO2 emissions achieved by the project		
	6	The ratio of renewable fuels in the local freight transport fuel mix in the project.		
	7	The total amount of material directly used in the city per capita		
	8	Total water consumption per capita per day		
	9	Percentage of houses equipped to reuse grey and rainwater		
	10	Annual total water abstraction as a percentage of available long-term freshwater resources in the geographically relevant area (basin) from which the city gets its water		
	11	Percentage of water loss of the total water consumption		
	12	Number of people per km2		
	13	Share of food consumption produced within a radius of 100 km		
	14	Share of brownfield area that has been redeveloped in the past period as a percentage of the total brownfield area		
	15	The extent to which the city has developed and implemented a climate-resilient strategy		
	16	The maximum difference in air temperature within the city compared to the countryside during the summer months		
	17	Percentage reduction in NOx emissions (NO and NO2) achieved by the project		
	18	Percentage reduction in PM2,5 emissions achieved by the project		
	19	Annual concentration of relevant air pollutants		
	20	Share of the population affected by noise >55 dB(a) at nighttime		
	21	The amount of municipal solid waste generated per capita annually		
	22	Percentage of city's solid waste that is recycled		
	23	Share of green and water surface area as a percentage of total land area		
	24	The net change in the number of native species		
Soe (2017) (D)	1	Urban Planning		
	2	Resource Management		
	3	Smart Buildings		
Mazza & Mavri (2019) (E)	1	quality and efficiency of the environment	5	Protection of Natural resources
	2	energy-efficient buildings,	6	waterways
	3	emissions CO2	7	Green Spaces and Parks
	4	water supply		

Matching colors indicate matching indicators

Table 3.4: Comparison of Indicators – Environment, Climate and Planet

ISO/CD 37122 (A)	1	The annual number of online visits to the municipal open data portal per 100 000 population
	2	Number of datasets offered on the municipal open data portal per 100 000 population
	3	Percentage of municipal datasets available to the public
	4	Percentage of city services accessible online
CITYkeys (C)	1	The extent to which administrative departments contribute to "smart city" initiatives and management
	2	The extent to which the smart city strategy has been assigned to one department/director and staff resources have been allocated
	3	The extent to which the progress towards a smart city and compliance with requirements is being monitored and reported
	4	The extent to which government information is published
	5	The number of projects in which citizens actively participated as a percentage of the total projects executed
	6	Number of public participation processes per 100.000 per year
	7	% of people that voted in the last municipal election as a share of the total population eligible to vote
	8	The extent to which the city has a supportive smart city policy
	9	Annual expenditures by the municipality for a transition towards a smart city
	10	The extent to which the city cooperates with other authorities from different levels
Soe (2017) (D)	1	Online services
	2	infrastructure
	3	open Government

Mazza & Mavri (2019) (E)	1	local institutions	5	Leadership
	2	Participation and partnership	6	Service
	3	transparency	7	application integration
	4	collaboration		

Matching colors indicate matching indicators

Table 3.5: Comparison of Indicators – Governance

ITU (B)	1	Student ICT Access	15	Poverty
	2	School Enrollment	16	Voter Participation
	3	Higher Education Degrees	17	Child Care Availability
	4	Adult Literacy	18	Natural Disaster-Related Deaths
	5	Electronic Health Records	19	Disaster-Related Economic Losses
	6	Life Expectancy	20	Resilience Plans
	7	Maternal Mortality Rate	21	Population Living in Disaster Prone Areas
	8	In-Patient Hospital Beds	22	Emergency Services Response Time
	9	Cultural Expenditure	23	Police Service
	10	Cultural Infrastructure	24	Fire Service
	11	Informal Settlements	25	Violent Crime Rate
	12	Housing Expenditure	26	Traffic Fatalities
	13	Gender Income Equity	27	Local Food Production
	14	Gini Coefficient		
CITYkeys (C)	1	Share of population with access to basic health care services within 500m		
	2	The extent to which policy efforts are undertaken to encourage a healthy lifestyle		
	3	Number of transportation fatalities per 100.000 population		
	4	Number of violence, annoyances, and crimes per 100.000 population		
	5	The level of cybersecurity of the cities' systems		
	6	The level of data protection by the city		
	7	Share of population with access to a public transport stop within 500m		
	8	Number of vehicles available for sharing per 100.000 inhabitants		
	9	% of bicycle paths and lanes to the length of streets (excluding motorways)		
	10	Share of population with access to at least one type of public amenity within 500m		
	11	Share of population with access to at least six types of commercial amenities providing goods for daily use within 500m		
	12	Fixed (wired)-broadband subscriptions per 100 inhabitants		
	13	The extent to which there is flexibility in delivery services		
	14	The extent to which the city provides easy access (either physically or digitally) to the wide coverage of educational resources		
	15	The percentage of schools with environmental education programs		
	16	Percentage of target group reached		
	17	Simpson Diversity Index of total housing stock in the project area		
	18	The extent to which preservation of the cultural heritage of the city is considered in urban planning		
	19	Percentage of the ground floor surface of buildings that are used for commercial or public purposes as a percentage of total ground floor surface		
	20	Square meters of public outdoor recreation space per capita		
	21	Green area (hectares) per 100.000 population		
	22	Access to educational resources		
	23	Digital literacy		
Soe (2017) (D)	1	Education		
	2	Inclusive society		
	3	Creativity		
Mazza & Mavri (2019) (E)	1	human capital	4	labor market efficiency
	2	lifelong learning education	5	health and personal safety
	3	creativity	6	quality of life

Matching colors indicate matching indicators

Table 3.6: Comparison of Indicators – Society, Culture, and People

	DIMENSION AND INDICATORS	Count
	Economy/ Prosperity Indicators	**5**
1	Annual number of new start-ups per 100 000 population	4
2	Unemployment Rate	4
3	No of innovation hubs in the city, whether private or public, per 100.000 inhabitants	3
4	R&D Expenditure	2
5	Youth Unemployment Rate	2
6	Percentage of the labor force employed in the ICT sector	2
	Environment Climate and Planet	**5**
7	Water Consumption	3
8	GHG Emissions	3
9	Green Areas	3
10	Solid Waste Treatment	2
11	Air Pollution	2
	Governance	**4**
12	Percentage of municipal datasets available to the public	4
13	Percentage of city services accessible online	3
14	Partnership and participation	2
	Society, Culture, and People	**4**
15	Student ICT Access	4
16	Violent Crime Rate	3
17	Cultural Infrastructure	2
18	Number of transportation fatalities per 100.000 population	2

Table 3.7: List of proposed 18 indicators for the Oeste smart region framework

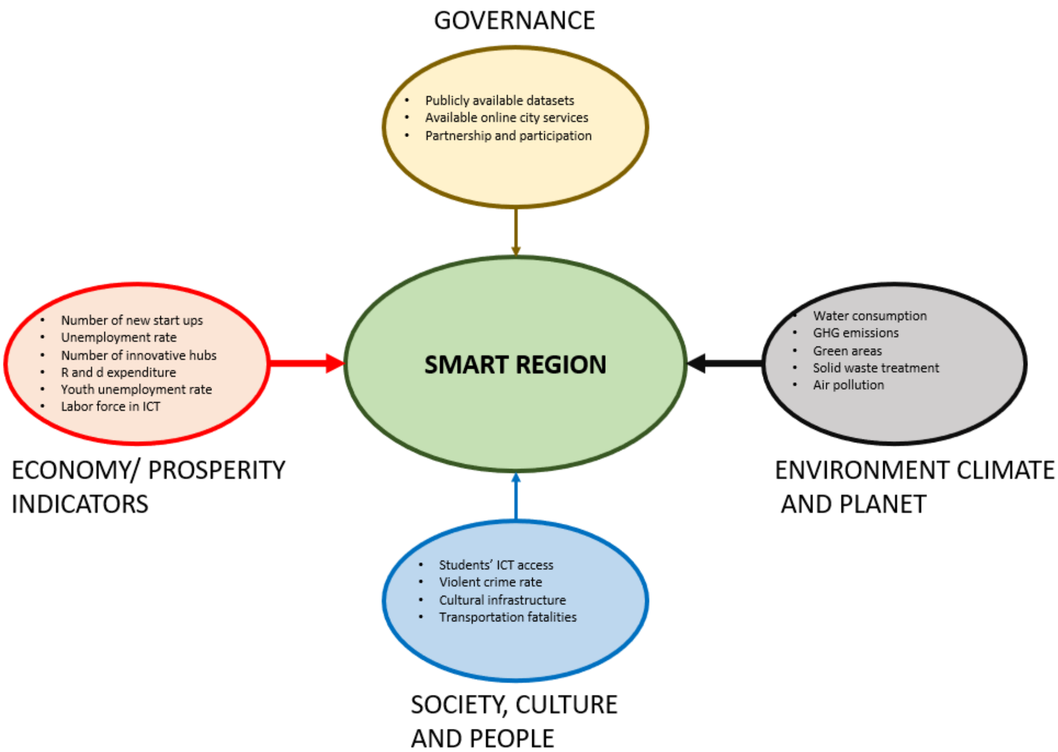

Fig 3.3: Oeste smart region conceptual framework

3.3 DATA AND DATA SOURCES

3.3.1 Sources of data for Smart region indicators

The data for the identified indicators were sourced from publicly available online open data. In the selection of the data to be used for the indicators, searches were conducted in open-source data sources for exact marches of the indicator data required. Data for six of these indicators were found. These are the annual number of new start-ups per 100 000 population, unemployment rate, green areas, solid waste treatment, violent crime rate, and number of transportation fatalities per 100.000 population. In a situation where an indicator data is not available, a proxy data is sourced as a replacement. Eight proxy data were use. These are Number of innovation hubs in the city, whether private or public, per 100.000 inhabitants represented by number of surviving ICT Enterprises born 1 year before; Percentage of the labor force employed in the ICT sector represented by number of tertiary employments; Water consumption is represented by percentage of dwellings connected to public water supply systems; GHG Emissions is represented by consumption of motor fuel by inhabitant (toe/ inhab.); Percentage of municipal datasets available to the public represented by Transparency index; Participation and partnership is represented by percentage of actual voters to registered voters in the elections for the Local Authorities; Student ICT Access represented by percentage of internet enable computers in primary school; and cultural Infrastructure represented by number of museums as a percentage of national number. The data to be used, proxy or not proxy, are presented in Table 3.8. Four indicators were unavailable.

	Economy/ Prosperity Indicators	**Selected Data**	**Source**
1	The annual number of new start-ups per 100 000 population	Birth of startups (%)	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826467
2	Unemployment Rate	Unemployment (%)	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826472
3	No of innovation hubs in the city, whether private or public, per 100.000 inhabitants	Survivals (No.) of ICT Enterprises born 1 year before by Geographic localization (ICT) %	https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0009707&contexto=bd&selTab=tab2
4	R&D Expenditure	NOT AVAILABLE	
5	Youth Unemployment Rate	NOT AVAILABLE	
6	Percentage of the labor force employed in the ICT sector	Employment, according to the Census: total and by sector of economic activity- tertiary	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826446

	Environment Climate and Planet	Selected Data	Source
7	Water Consumption	Dwellings connected to public water supply systems (%)	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5825773
8	GHG Emissions	Consumption of motor fuel by inhabitant (toe/inhab.) by Place of residence	https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_indicadores&indOcorrCod=0008158&contexto=bd&selTab=tab2
9	Green Areas	Landuse map	https://www.dgterritorio.gov.pt/dados-abertos
10	Solid Waste Treatment	Urban waste management hierarchy index	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826439
11	Air Pollution	NOT AVAILABLE	
	Governance	**Selected Data**	**Source**
12	Percentage of municipal datasets available to the public	Transparency index	https://transparencia.pt/wp-content/uploads/2020/11/Relato%CC%81rio-ITM-2013.pdf
13	Percentage of city services accessible online	NOT AVAILABLE	
14	Participation and partnership	Percentage of voters to Registered actual voters in the elections for the Local Authorities	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826482
	Society, Culture, and People	**Selected Data**	**Source**
15	Student ICT Access	Percentage of internet enable computers in primary school	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826484
16	Violent Crime Rate	Crimes registered by police per thousand inhabitants	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826442
17	Cultural Infrastructure	Museums: percentage of national	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826485
18	Number of transportation fatalities per 100.000 population	deaths in road traffic accidents as a percentage of mainland	https://www.pordata.pt/en/DB/Municipalities/Search+Environment/Table/5826486

Table 3.8 Indicators, Selected data and proxies, and sources

3.3.2 Data Description

A description of the selected indicators is provided in this section.

		Data (Indicator)	DESCRIPTION
ECONOMY	1	Birth of startups	This data presents the birth rate of non-financial enterprises in the region. It is a percentage describing how many non-financial enterprises are born in each municipality of the region annually
	2	Unemployment Rate	This data presents the Unemployed residents who are registered at the public employment office as a percentage of the total number of resident populations aged 15 to 64.
	3	Survivals (No.) of ICT Enterprises	The number of ICT-based enterprises that survive the first year of registration. This data was converted to a percentage change in

		born 1 year before by (%)	survival by finding the difference between a year and the preceding year, divided by the number in the preceding year multiplied by 100.
	4	R&D Expenditure	This is not available at the municipal granularity and no proxy was found
	5	Youth Unemployment Rate	This is not available at the municipal granularity and no proxy was found.
	6	Employment in tertiary	This data presents the number of people who are employed in the tertiary sector of the economy to which ICT was classified. This data was converted to a percentage change in survival by finding the difference between a year and the preceding year, divided by the number in the preceding year multiplied by 100.
ENVIRONMENT	7	Dwellings connected to public water supply systems (%)	This presents the percentage of all homes in each municipality that is connected to a public water supply.
	8	Consumption of motor fuel by inhabitant (toe/ inhab.) by Place of residence	This presents the tonnage of car fuel that is used in each municipality per capita. It is obtained by dividing the number of tonnes of fuel by the number of residents. This data was converted to a percentage change in survival by finding the difference between a year and the preceding year, divided by the number in the preceding year multiplied by 100
	9	Green Areas	This refers to the square kilometers of land classified as a green area in each municipality the region. This data is available and was used.
	10	waste management hierarchy index	The waste management hierarchy index is an index used to describe the most environmentally friendly methods of waste management. It measures the performance of an environment by giving top priority to waste prevention, followed by re-use, recycling, recovery, and finally disposal.
	11	Air Pollution	This is not available at the municipal granularity and no proxy was found.
GOVERNANCE	12	The transparency index	This refers to the measure of the ability of a government to make public all acts of government and their representatives, to provide society civil service with relevant information in full, reliable, timely, easily understandable and easily accessible.
	13	Percentage of city services accessible online	This is not available at the municipal granularity and no proxy was found.
	14	Percentage of voters to Registered voters in the elections for the Local Authorities	This refers to the percentage of registered voters in each municipality that participated in local elections
PEOPLE	15	Percentage of internet enable computers in primary school	This refers to the Computers with Internet connection as a percentage of total computers in primary schools
	16	Crime data	This is the number of crimes registered by police per thousand inhabitants.
	17	Museums	This data captures the number of museums as a percentage of national
	18	The number of fatalities from road transport	The number of deaths in road traffic accidents as a percentage of total in continental Portugal.

Table 3.9 Description of Data used

3.3.3 ETL process

The data for the analysis was gotten from 3 sources, pordata, ine, and transperencia.pt. Table:3.9 presents the ETL process adopted in preparing the data for analysis.

EXTRACT			TRANSFORM			LOAD
Data (Indicator)	**Source**	FORMAT	RSTUDIO			POWER BI
Birth of startups (%)	pordata	HTML	Scrape	Selected and filtered relevant columns and rows, gather, and mutate, multiplied by -1	Append to Fact Table	Load Fact Table Normalize data Load Dimension Tables Create data model Create Dashboard
Unemployment (%)	pordata	HTML	Scrape		Append to Fact Table	
Survivals ICT %	ine	csv	Download	Read, Selected, and filtered relevant columns and rows, gather and mutate	Append to Fact Table	
Tertiary economy employed	pordata	HTML	Scrape	Selected and filtered relevant columns and rows, gather, and mutate (convert to %)	Append to Fact Table	
Water supply systems (%)	pordata	HTML	Scrape		Append to Fact Table	
Fuel consumption	ine	csv	Download	Read, Selected, and filtered relevant columns and rows, gather, and mutate (convert to % and multiplied by -1)	Append to Fact Table	
Landuse map	Dados abertos|DGT	HTML	Download	Spatial join with municipalities map.	Append to Fact Table	
Waste management hierarchy index	pordata	HTML	Scrape	Selected and filtered relevant columns and rows, gather and mutate	Append to Fact Table	
Transparency index	transparencia.pt	csv	Download	Read, Selected, and filtered relevant columns and rows, gathered and mutate	Append to Fact Table	
Voters Local Authorities	pordata	HTML	Scrape	Selected and filtered relevant columns and rows, gather and mutate (convert to %) multiplied crimes and death by -1	Append to Fact Table	
Computers with Internet in pry school	pordata	HTML	Scrape		Append to Fact Table	
Crimes per thousand	pordata	HTML	Scrape		Append to Fact Table	
Museums	pordata	HTML	Scrape		Append to Fact Table	
Deaths on road	pordata	HTML	Scrape		Append to Fact Table	

Table 3.9 ETL Process

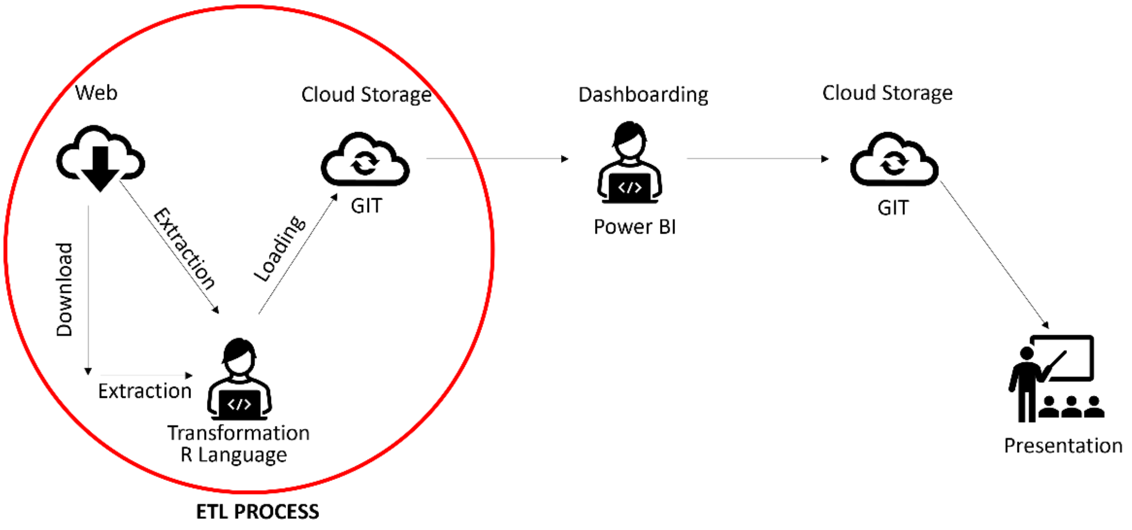

Fig 3.4 Analysis Workflow

To ensure reproducibility of research and improve data processing speed, the ETL process was performed and stored on github (https://github.com/olatokeoluwole/OESTE-SMART-REGION.git). The dashboard was then created on github,

3.4 COMPARISON OF SELECTED INDICATORS WITH THE SDGS

	Birth rate of startups	Computers with internet	Crime per 1000 population	Employed in ICT	Fuel per resident	ICT survival	Percentage of museum	Road fatalities percent	Transparency index	Unemployment rate	Voters in local elections	Waste management index	Water supply	Green area
GOAL 1: No Poverty	X	X	X	X		X			X	X		X		
GOAL 2: Zero Hunger	X	X	X	X		X			X	X		X		
GOAL 3: Good Health and Well-being					X		X	X				X	X	X
GOAL 4: Quality Education		X		X			X		X					
GOAL 5: Gender Equality		X	X	X							X		X	
GOAL 6: Clean Water and Sanitation												X	X	X
GOAL 7: Affordable and Clean Energy					X							X		
GOAL 8: Decent Work and Economic Growth	X	X	X	X		X			X	X				
GOAL 9: Industry, Innovation, and Infrastructure	X	X		X		X		X	X	X		X		
GOAL 10: Reduced Inequality	X	X		X						X	X			
GOAL 11: Sustainable Cities and Communities	X		X	X	X	X		X		X	X	X	X	X
GOAL 12: Responsible Consumption and Production					X							X	X	
GOAL 13: Climate Action					X							X	X	X
GOAL 14: Life Below Water												X	X	
GOAL 15: Life on Land					X							X	X	X
GOAL 16: Peace and Justice Strong Institutions			X						X	X	X			X
GOAL 17: Partnerships to achieve the Goal			X								X	X	X	X

Table 3.11 Comparison of Indicators with SDGs

To benchmark the selected indicators against current global efforts aimed at achieving sustainable development, the indicators were compared with 17 SDG goals. In doing this, each indicator was compared with each of 169 targets of the SDGs. It was found that the indicators check every goal of the SDGs at least two times. The implication of this is that if these indicators are achieved, it will have a positive influence on all the SDGs.

3.5 Dashboards and Uses of Dashboards

Dashboards are diagnostic tools designed to provide busy managers with a quick overview of a company's performance (Velcu and Yigitbasioglu, 2012). They are a variety of decision support systems (Arnott and Pervan, 2005) and are tools for easy and fast transformation and revelation of 'hidden' information in data (Damyanov and Tsankov, 2019). The strength of dashboards is in their strong use of visual and functional features to aid the understanding of complex data. The dashboard, therefore, helps to solve the problem of information overload (Abduldaem and Gravell, 2019)

Earlier studies, (Velcu & Yigitbasioglu, 2012 and Abduldaem & Gravell, 2019)), have shown that dashboards are effective tools for the following uses: monitoring, problem-solving, rationalization, communication and consistency, and performance management. Velcu and Yigitbasioglu, (2012) further noted that there is a high correlation between the use of dashboards and user productivity. Recent development in dashboard features including scenario analysis, drill-down and flexible presentation capabilities have further improved the effectiveness of these tools and their wider acceptance in various fields. While dashboards have been extensively used in business intelligence, it has in recent years also found usefulness in other domain as education (Damyanov and Tsankov, 2019), environmental monitoring (Filonik, Medland, Foth, Rittenbruch, 2013), healthcare Zhang et al, 2011 and Smart city performance monitoring (Jing et al, 2019).

3.5.1 Dashboard design

The design of the project dashboard and its functionalities will be guided by the features diagram developed by Damyanov and Tsankov, (2019) and is presented in Fig 3.6. the features diagram is in 6 levels of hierarchy. This hierarchy of functionalities to be considered when designing a dashboard is the feeding, how data will be fetched into the dashboard, its appearance, should the presentation be graphic or tabular. The interactivity functions should also be considered, this could be filtering, selection, drill-down, sorting, grouping, zooming, change appearance, or accumulation. The fourth consideration is the type of datasets and the fifth is the type of interoperability, that is the types of formats that the dashboard can either import data or export data. Finally, the sixth refers to the types of feedback mechanisms it would have.

In the design of this dashboard, the overarching principle adopted is the presentation of all indicators in a single display. This requires the systematic selection of data that should be included in the default display. It is important to display the most relevant data as default. The less relevant data is displayed using the tooltip capability of Power BI. It was therefore decided that the regional data are presented as default while municipalities data would be accessed using tooltips.

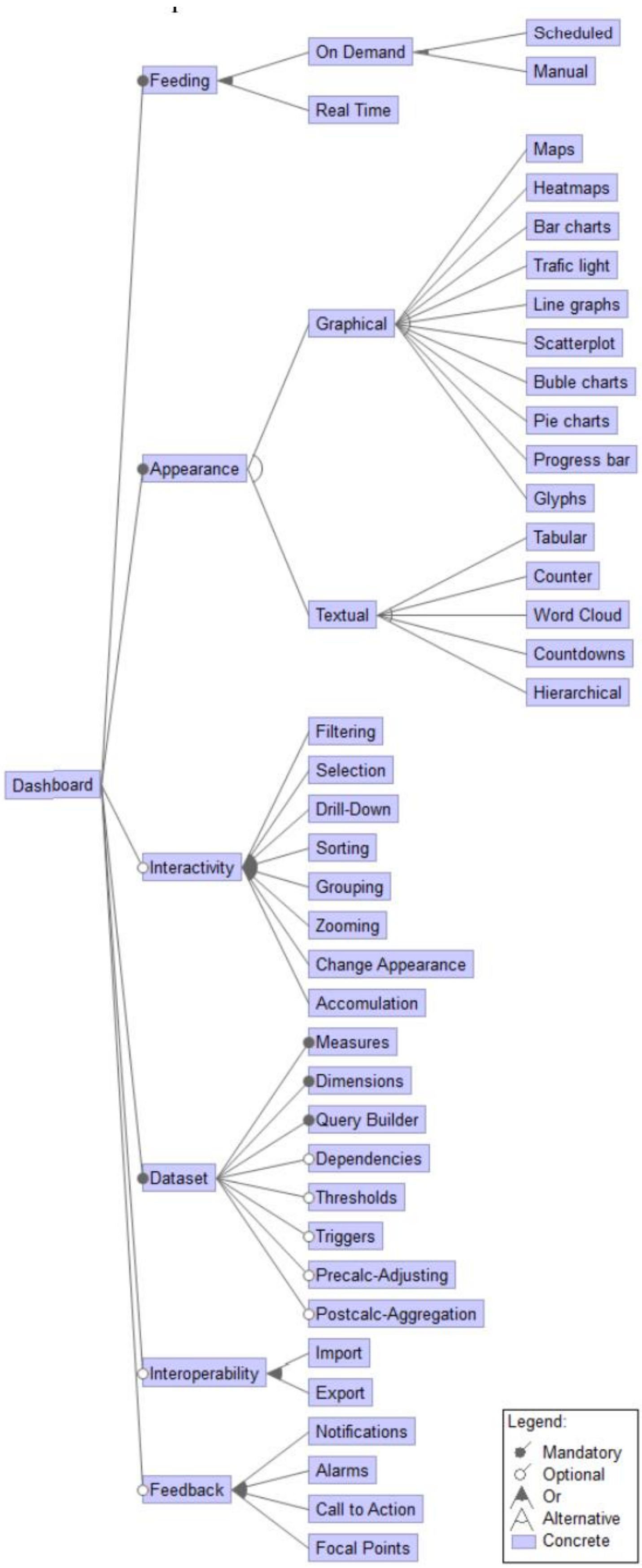

Fig 3.5: Dashboard features diagram by Damyanov and Tsankov, 2019

3.5.2 Design of Data model

To develop a functional dashboard, it is important to design a data model which will determine how the data will relate and enable fast analysis and retrieval of information. The design used for the data model embodies the indicators to be measured and monitored by the dashboard. The model adopted is a Star Schema with a small fact table that has data and three dimension tables, these are municipality, date, and indicator as is shown in Figure 3.4.

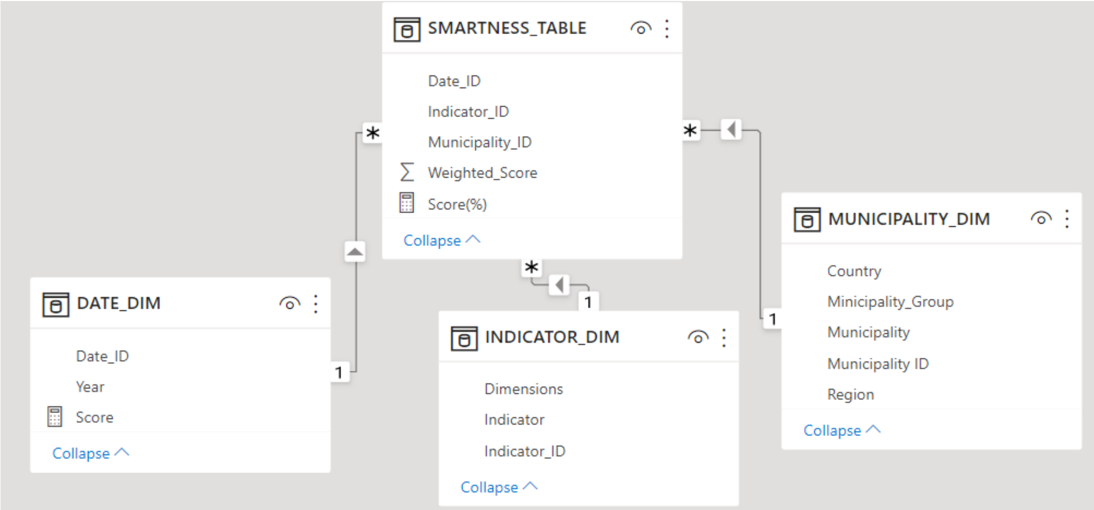

Fig 3.6 Proposed Star Schema for the data model

Some of the names of the indicators are too lengthy to be included in the dashboard. To solve this problem, a naming convention for the dashboard was developed to provide shorter and more dashboard-friendly names. The naming convention of indicators in the dashboard is presented in Table 3.11

Dimension	S/No	**Data (Indicator)**	**Naming Convention**
ECONOMY	1	Birth of startups	Birth of Startups
	2	Unemployment Rate	Unemployment Rate
	3	Survivals (No.) of ICT Enterprises born 1 year before by (%)	ICT Survival
	4	Employment in tertiary	Employment Tertiary
ENVIRONMENT	5	Dwellings connected to public water supply systems (%)	Dwellings with Water
	6	Consumption of motor fuel by inhabitant (toe/ inhab.) by Place of residence	Fuel consumption
	7	Green Areas	Green Areas
	8	waste management hierarchy index	Waste Index
GOVERNANCE	9	The transparency index	Transparency Index
	10	Percentage of voters to Registered voters in the elections for the Local Authorities	Voters in Elections
PEOPLE	11	Percentage of internet enable computers in primary school	Compute with Internet
	12	Crime data	Crime Data
	13	Museums	Museums
	14	The number of fatalities from road transport	Road Fatalities

Table 3.12 Naming Convention of Indicators

It is noteworthy that there exists a large variation in the values of the indicators measured in the framework. In other to bring these values into the same scale, these values were normalized to range between 0 and 1. Therefore, the values of indicators after the normalization process are referred to as points.

The current regional score is derived by summing all points obtained in all indicators at the region scale, dividing this sum by the maximum possible sum of points (2316), and multiplying this by 100.

Current Regional Score = **(Σ (Obtained Points in Region)/ Σ (Max Obtainable Points)) *100**

To derive the municipality score, the sum of all points obtained by all indicators at the municipality scale is divided by the sum of the maximum possible points (2316) and multiplied by 100.

Municipality Score **= (Σ (Obtained Points in Municipality)/ Σ (Max Obtainable Points)) *100**

The target regional score on the dashboard is the proposed regional score when the projected slider is set to an expected regional goal.

Target Regional Score = **(Σ (Target Points in Region)/ Σ (Max Obtainable Points)) *100**

3.5.3 Proposed Structure of the dashboard

The proposed structure of the dashboard design fig 3.5 is to have an opening dashboard that provides an overview of the smartness of the region by presenting the indexes for the dimensions and an overall smart index for the Oeste region. After this opening page, three (3) tabs for each framework dimension are provided for further information about the indicators of each dimension. Fig 3.7 to 3.13.

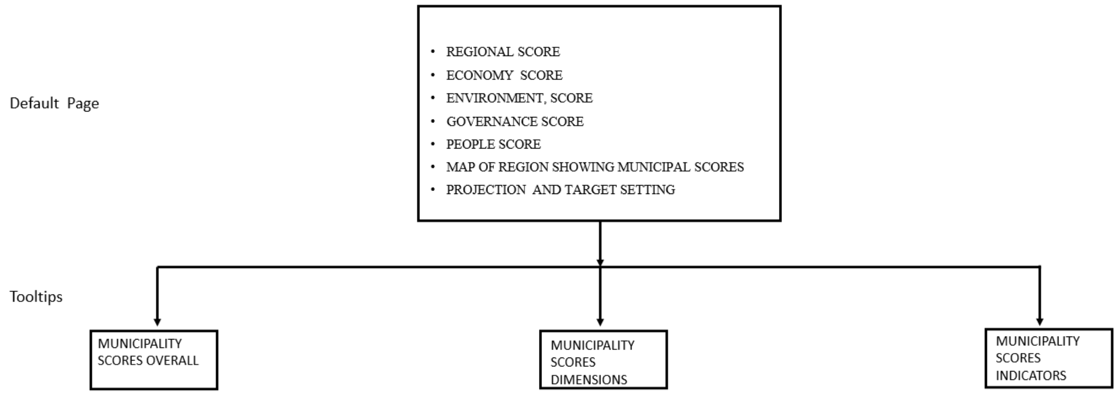

Fig 3.7 Proposed Structure of the dashboard

3.5.4 Proposed operational capabilities of the dashboard

1. The proposed dashboard is expected to provide the following visualizations.
2. Present a number which sums the overall performance of the region
3. Present the score for each dimension.
4. Present the score for each indicator.
5. Present a number that sums the overall performance of each municipality
6. Present performance of each municipality by the different dimensions.
7. Present performance of each municipality by the different indicators.
8. Choropleth map of the scores of the municipalities of the region.
9. The dashboard is also expected to have capabilities to propose targets by indicator, dimension, and municipalities for the region.

3.5.5 Mock-up

A mock-up of the dashboard is presented here. The default page of the dashboard would display indicator, dimension, and municipality data from the regional level of view. The dashboard would then use tooltips to present municipality data. This would ensure that the entire performance of the region can be seen in only one view of the dashboard.

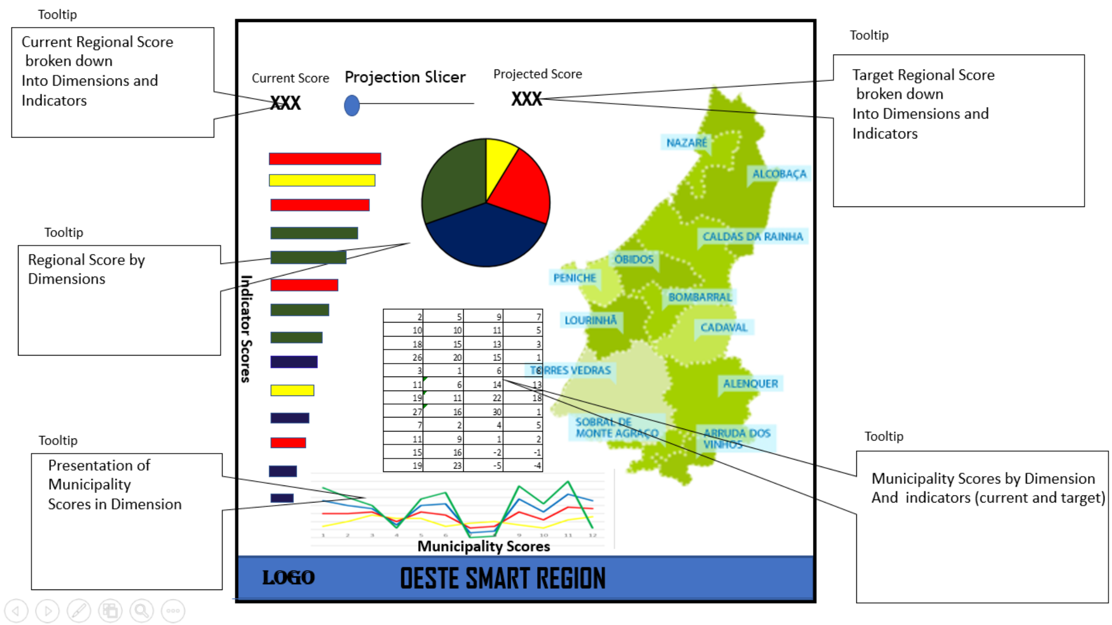

Fig 3.8 Proposed Dashboard Opening page

In designing the mock-up, four (4) principles were followed. These are:

1. One page: the dashboard should provide all the information on one page, for it to truly be a dashboard, it would not use multiple tabs.

2. Regional data – default: The content of the default screen would display only data which are relevant to regional scale.

3. Municipality data – tooltip: Information at the municipal scale will be treated as details of the region and would be presented using tooltips

4. Key data shown as headline: It is assumed that the value of the space on display in a dashboard decreases from top to bottom. The display of information should also follow this same pattern. Therefore, the most important data relevant to the performance of the smart region are provided at the top of the dashboard while least relevant are provided at the bottom.

4 RESULTS

4.1 CURRENT REGIONAL SCORE

This chapter of the report commences with a discussion on the performance of the Smart region as assessed at the Dimension and indicator levels. The second section discusses the spatial variation in dimension performance of the twelve (12) municipalities comprising the Oeste region. The final section of the chapter demonstrates the use of the projection slider capability of the dashboard to project a 10 percent increase in the performance of the Oeste Smart Region and discusses what expected goals which the municipalities would set as targets.

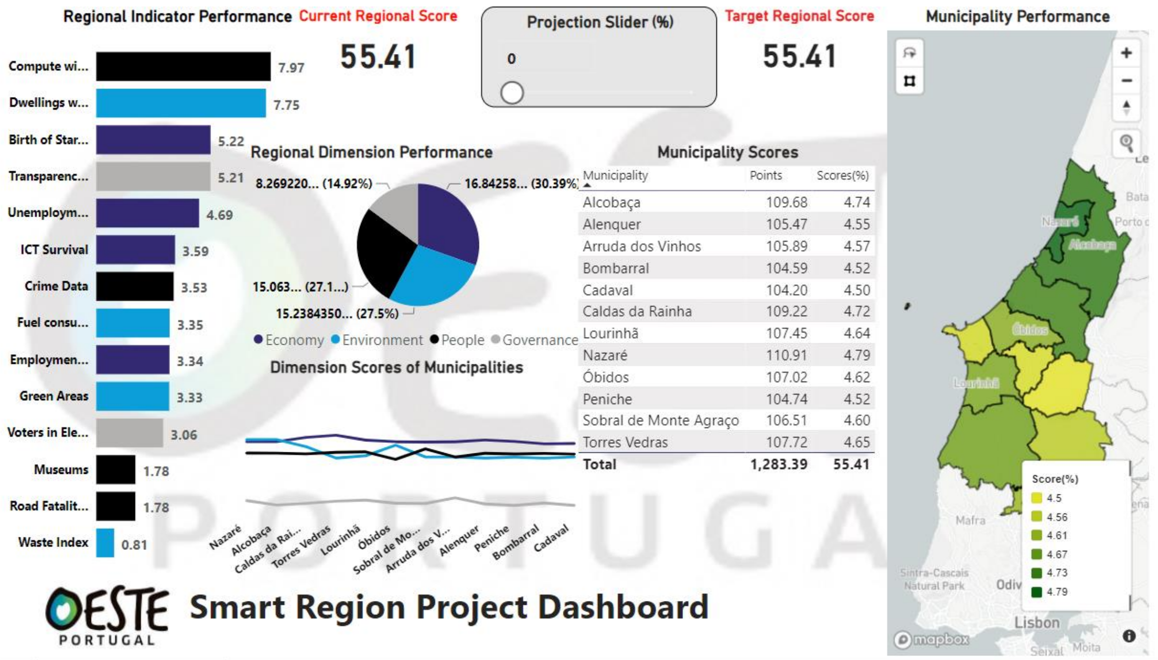

Fig 4.1 Default Dashboard view

4.1.1 Regional Score

From the card to the left of the slider in Fig 4.1, it can be noted that the current regional smart score of the Oeste region is 55.41 (%) this means that the region scored a total of 1,283.39 points of a maximum possible score of 2316 points. The detail of this score is presented in the following sections along the lines of the regions' four (4) dimensions and fourteen (14) indicators.

4.1.2 Regional Dimensions

The pie chart (also in Fig 4.1) shows the performance of the region at the level of the four (4) dimensions. It reveals that of the 55.41% Regional score by the region, the Economy performed highest contributing 30.39% of the total. The economy is followed by Environment with 27.5%, People contributed, 27.1%, and Governance, 14.92%.

A cursory look at the data, presented in the line graph at the bottom of the dashboard reveals that while the leading municipality, when all dimensions are considered is Nazaré, the municipality with the highest score in the economy is Torres Vedras, with 1.47% (34.03 points), the lowest-performing in the economy is Bombarral with 1.37% (31.70 points) In Environment, the highest point is scored by Alcobaça, with 1.42% (32.85 points), and the lowest Bombarral scored 1.20% (27.87 points). in People, the highest and lowest scores were in Sobral de Monte Agraço and

Óbidos with 1.31% (30.39 points) and 1.19% (27.57points) scores respectively. Lastly, in Governance, with a score of 0.74% (17.24 points), Arruda dos Vinhos leads the dimension while Cadaval is least with a score of 0.66% (15.24 points).

4.1.3 Regional Indicators

At the level of performance indicators, the highest performing indicator, as seen by the horizontal bar chart, is the percentage of computers in primary schools which have internet access, with a score of 7.97% (184.49 points). this is followed by the percentage of homes that are connected to the public water supply., the birth rate of startups, transparency index, unemployment rate, ICT firms' survival rate, crime, and motor fuel consumption rate. These are with scores 7.75% (179.4 points), 5.22% (120.79 points), 5.21% (120.74 points), 4.69% (108.87 points), 3.59% (81.8 points), and 3.35% (77.6 points) respectively. The remaining indicators are employment in tertiary level of employment, the percentage of green area, voter participation in local elections, number of museums road fatalities, and waste management index. These scored 3.34% (77.36 points), 3.33% (77.1 points), 3.06% (70.76 points), 1.78% (41.32 points), 1.78% (41. 27 points), and 0.81% (18.32 points) respectively.

4.2 SPATIAL VARIATION AMONG MUNICIPALITIES

The Table left of the map in Fig 4.1 presents the overall scores of each municipality. With a score of 4.79% (109.68 points), Nazaré leads the municipalities while Cadaval trails with 4.50% (104.59 points).

A study of the map in Fig 4.1 reveals the spatial variation in the performance of the municipalities. The three (3) northern municipalities of Nazaré, Alcobaça, and Caldas da Rainha exhibit the highest values while the central municipalities have the lowest.

4.3 TEN PERCENT PERFORMANCE PROJECTION

One of the proposed uses of the dashboard is to serve as a tool for regional development planning. The ability to set development targets for the region informed the decision to include a performance slider in the dashboard. The function of the projection slider is to provide a tool for the setting of smart regional development goals. This goal is in the form of percentage increase of current regional score. When this increase is set, the implications of the set increase is calculated over each municipality, dimension, and indicator. This allows the users to understand the consequences of these increases along these lines. This section demonstrates the use of the dashboard as a smart regional development planning tool. The projection slider was set at a proposed improved score of 10%. Fig 4.2 presents the expected implications for the region at the dimension, indicator, and municipality levels.

Tables 4.1 and 4.2 summarize the expected scores of the dimension, indicator, and municipality levels to achieve a 10% increase in the overall smart region score.

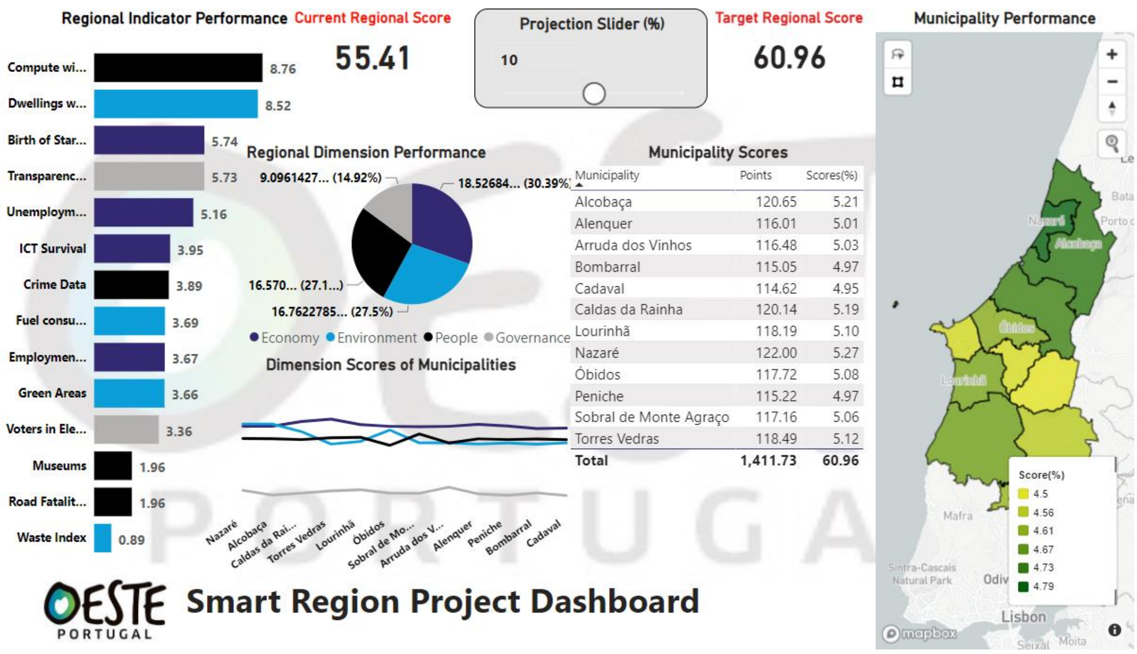

Fig 4.2 Performance at project rate of 10%

Dimension	Target	Indicator	Target	Points
Economy	429.1	Birth of Startups	8.76	132.87
		Unemployment Rate	8.52	119.53
		ICT Survival	5.74	91.58
		Employment Tertiary	5.73	85.09
Environment	388.2	Dwellings with Water	5.16	197.34
		Fuel consumption	3.95	85.36
		Green Areas	3.89	84.81
		Waste Index	3.69	20.71
People	180.8	Compute with Internet	3.67	202.94
		Crime Data	3.66	89.98
		Museums	3.36	45.45
		Road Fatalities	1.96	45.39
Governance	413.6	Transparency Index	1.96	132.81
		Voters in Elections	0.89	77.86
Total	1411.72	Total		1411.72

Table 4.1 Targets for Dimensions and Indicators to achieve 10% improvement

Municipalities	Target
Alcobaça	120.65
Alenquer	116.01
Arruda dos Vinhos	116.48
Bombarral	115.05
Cadaval	114.62
Caldas da Rainha	120.14
Lourinhã	118.19
Nazaré	122
Óbidos	117.72
Peniche	115.22
Sobral de Monte Agraço	117.16
Torres Vedras	118.48
Total	1411.72

Table 4.2: Targets for Municipalities to achieve 10% improvement

This chapter discussed the performance of the Smart region as assessed at the dimension and indicator levels. It also provides a discussion on the spatial variation in dimension performance of the twelve (12) municipalities comprising the Oeste region. Finally, it demonstrated the use of the projection slider capability of the dashboard at a 10 percent increase in the performance of the Oeste Smart Region and discusses what expected targets which the municipalities would set.

5 CONCLUSIONS

The aim of this project is to develop a framework for the assessment, as well as an interactive dashboard as a tool for the monitoring and evaluation, of the Oeste smart region. To achieve this aim, a design research approach was adopted. Specifically, Peffers et al. (2007) six (6) steps we adopted for the design. The study also adopted a reproducibility of research philosophy as an overarching goal.

In implementing the Peffers et al (2007) six steps, the study started by identifying the problem to be solved as the development of a means of monitoring and evaluating Smart region progress for Oeste. The objectives of the study were set as both systematically selecting relevant data for dimensions and indicators. The next step involved creating a data model using the selected indicators, systematically determining how the different dimensions and indicators will relate (i.e., model), and displaying them on a dashboard. This dashboard would be presented to representatives of the Oeste region to collect feedback. This feedback would then be implemented in the dashboard, to improve its performance.

To ensure reproducibility, the ETL process, dashboard construction, and data visualization were performed in github and the link to the github site was provided. This provided the added advantage of reducing the size of the power BI file and making the dashboard run updates automatically.

In achieving the study aim and objectives, this thesis reviewed five (5) frameworks identifies a set of four (4) dimensions and eighteen (18) indicators germane to the development of a smart region. These dimensions and indicators were adopted in the construction of a conceptual framework for the smart regions. To apply the conceptual model to Oeste smart region, data needed to measure the identified indicators were then sourced from publicly available data websites. These are pordata, ine, Dados abertos, and transparencia.pt. It was however noted that four (4) of the eighteen indicators were not available and so fourteen indicators were used to build a data model with one fact table and three dimensions forming a star schema.

The developed star schema data model was then used as the basis for the development of an interactive dashboard which comprises visuals that present current performance of the region along the fourteen available indicators. The dashboard summarizes the performance of the region in the form of a current regional score. and brakes down this performance into indicators, dimensions, and municipalities. To gain further insights about performance of municipalities, the dashboard adopted the use of tooltips. Using the tooltips, the dashboard provides the performance of municipalities by indicators and dimensions.

Another capability of the dashboard is the ability to be used as a regional development planning tool. By including a slider, target performance of the region can be set as a percentage increase of current performance and the implication of this increase can be seen on the indicators, dimensions, and municipalities. This enables the user to set targets for specific duration and identify the expected increase in the indicator, dimension, and municipalities. Both the measurement and the target capacities of the dashboard were demonstrated in this report.

5.1 LIMITATIONS OF THE PROJECT

Three major limitations were observed in this study are:

1. Lack of available open-source data- some of the selected indicators were found not to have available data at the required granularity or timestamp. The implication of this is that these unavailable data were excluded from the outcome of the project.

2. Lack of centralized database for the region- currently, the Oeste region is lacking in a central database where the data for these indicators can be centrally pulled into the dashboard. The implication of this for the thesis is that data had to be pulled in from various sources and undergo different transformation processes to be used. More importantly, the lack of a centralized database for the region and the pull from different source implies that the region does not have control over these sources and cannot update data which are relevant to the region.

3. Incompatible data formats- Some of the data that were available and up to date, were available in PDF format which would require some transformation before it would become usable. The implication of this is that updating data gives room for the possibility of error.

4. Time Constraint- To get further feedback from stakeholders, the dashboard would have been presented to representatives of the Oeste region.

5.2 FUTURE WORK RECOMMENDATIONS

The following suggestions are made for future work:

Stakeholder Presentation: The presentation and demonstration of the dashboard to stakeholders representing Oeste region is suggested as a future work. The event would be an opportunity for future users of the dashboard to assess its functions and provide feedback. This feedback would be useful to further enhance the performance of the dashboard.

Development of a centralized database for the region- As a proposition for future work, A centralized database should be developed for the region. This proposed database should be designed to have two functionalities. These are the puling of data from municipal databases and the feeding of data to the dashboard. This approach would ensure that there is a continuous stream of data municipalities through the regional database into the dashboard.

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