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Mestrado em Gestão de Informação
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Monitoring Smart Sustainable Cities

Business Intelligence approach to Smart Sustainable Cities

Nuno Miguel Valentim Charneira

Project Work report presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Business Intelligence and Knowledge Management

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MONITORING SMART SUSTAINABLE CITIES

by

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Advisor: Prof. Miguel de Castro Neto, Phd

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DEDICATION

This work is dedicated specially to my family for always pushing me towards my objectives in more ways than I could ask for.

To my grandfather for all his support and for sharing of what makes me happy.

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ABSTRACT

Sustainability is one of the upmost important topics in the 21st century for the human being and it is a concept to which communities need to thrive for, communities like cities, that as time passes gather a larger number of people. As the cities evolve in population size so must their means of management, and as such, Smart Cities develop means to better operate and serve their population. Many of those means have a base in data gathering for a better understanding of their environment, this master's project intends to develop a meaningful way of monitoring a Smart City's sustainability making use of open source data that's gathered for such purpose. Using Business Intelligence tools this project aims at developing informative dashboards that can in a clear, concise, and practical way, monitor the performance of a city's sustainability having into account several indicators identified as being key performance indicators for sustainability.

KEYWORDS

Smart City; Sustainability; Business Intelligence; Dashboard; Monitoring; Power BI; Data

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LIST OF ABBREVIATIONS AND ACRONYMS

AQE	Air Quality and Environment
BI	Business Intelligence
DSR	Design Science Research
ESC	Economy and Social Conditions
ISO	International Organization for Standardization
KPI	Key Performance Indicator
PM	Particulate Matter
WWM	Waste and Wastewater Management

1. INTRODUCTION

The topics of environmental awareness and sustainability for the future have never been of such importance as in the XXI century and with the continuous development of technology as well as the growing interest and need of the human race to be sustainable, the concept of Smart Sustainable City emerge. It is a standard of human development that is found ever more prominent all over the world in urban development.

Having a focus on Lisbon city in Portugal, the aim of the project is to facilitate an informative dashboard using Business Intelligence (BI) tools, namely Microsoft's Power BI for Microsoft's classification as a leader in Analytics and BI Platforms (Richardson et al., 2020), and applying knowledge developed in the information management area. The dashboard should have as base data open-source data that is collected about the city and made available to the public through public organizations.

The dashboard in its final stage should provide easily readable information about the city's sustainability, making monitorization of the city's efforts to better itself for the future a simplified and accessible task. There should be evolution over time and performance of indicators of importance for sustainability as indicated by established international organizations.

As such, taking advantage of a smart and connected city that provides open-source data, the objective of the project is to create a base that monitors a city's sustainability efforts but that can also evolve, if there is an investment in data gathering, for a better growth of smart sustainable cities which in light of the modern world needs is of extreme use.

1.1 Project Relevance

The project is of special relevance when having in mind the present and future state of the planet Earth, the environmental predictions look dire for the planet's sustainability. In this sense, the efforts made by humankind to create sustainable future must be measured and evaluated.

The United Nations indicate an estimated 50 percent of the global population reside in this moment in urban centres, about 3.5 billion people, and urban development has been growing over time. It is projected that this number will increase to 5 billion people by the year 2030. The impact cities have on the environment is in fact very visible and measurable, while only just occupying 3 percent of the Earth's land, city's energy consumption is estimated at around 60 to 80 percent of the globe's total energy consumption and carbon emissions are measured at about 75 percent of all global carbon emissions according to the UN. (United Nations, 2020)

Considering these statistics governments and organizations have been making efforts to combat this course. Agendas, awards and rankings are in place to help guide governments and stakeholders to sustainability goals, such as the United Nations 17 Sustainable Development Goals Agenda for 2030, the European Green Leaf Awards, the C40 Cities Award and the European Green Capital Award for which Lisbon has been nominated as Green Capital of Europe for 2020 for it's developments in energy efficiency, water management and green solutions implemented in the latest years.

Connecting these efforts to the information management area there is a space to develop management-like analysis to past and current state of the city's sustainability indicators, much like an organization would analyse and monitor their performance in their business, the city can monitor their performance towards its objectives.

The objectives a city may have towards sustainability may touch on several topics and areas of urban management. In this sense the project should introduce consolidation of information and clear definition of indicators.

1.2 Methodology

For this project the followed methodology is the Design Science Research (DSR) methodology that aids researchers in the creation of artifacts to solve problems in the field of Information Systems (Vaishnavi & Kuechler, 2004/21).

The DSR methodology follows a process model also identified as the DSR cycle. In this model there are process steps that create outputs and through each process step there can be knowledge flows (Figure 1).

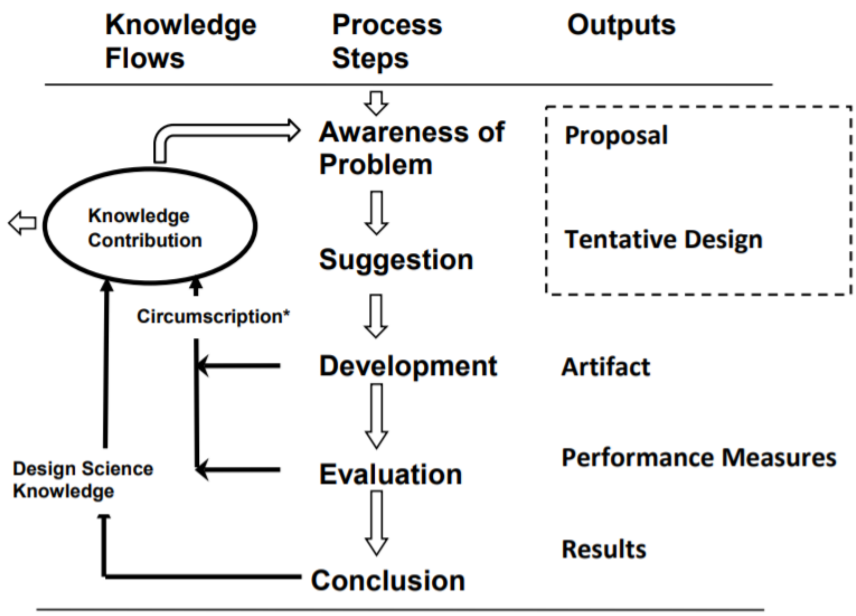


Figure 1 - Design Science Research Process Model

Five process steps are defined: Awareness of Problem, Suggestion, Development, Evaluation and Conclusion. Vaishnavi & Kuechler (2004/21) define each process as follows.

1. Awareness of Problem: the identification of an interesting research problem that can come from several different sources. For this project the awareness of the problem is reviewed in the Introduction and Project Relevance chapters.

2. Suggestion: from the suggestion step comes a Tentative Design and the proposal of a prototype. This is the creative part of the process where new functionality is envisioned. This step is embodied in the Conceptual Model chapter of the project, where prototypes of the artifacts to be developed are proposed in the form of measures, indicators, data model and dashboards.

3. Development: the proposed Tentative design previously mentioned is developed in this stage. The artifacts to be constructed determine the tools and techniques required for development. The Development chapter describes this process step of the DSR cycle.

4. Evaluation: this step evaluates if expectations, either implicit or explicitly defined in the proposal are met by the developed artifacts. The final artifact will be evaluated in meeting its proposed objective. For the design science researcher, the result of this phase and information gained from the construction of the artifact may result in another round of Suggestion.

5. Conclusion: it is the finale of the research cycle where the results of the research and knowledge gained is often categorized as learned facts or behavior that can be repeatedly applied or anomalous behavior that may be the subject for further research.

2. LITERATURE REVIEW

2.1 Sustainable Development in Communities

The concept of sustainable development was best described in the 1987 World Commission on Environment and Development Brundtland report entitled "*Our Common Future*", a report that had envisioned "*to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond*" (United Nations, 1987). In the Brundland report sustainable development is described as humanity having the "*ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs*" (United Nations, 1987).

Since this report was presented, the United Nations has developed efforts to drive sustainable development across the globe, such as Agenda 21 in 1992's United Nations Conference on Environment & Development in Rio de Janeiro, Brazil, the "Earth Summit". This Agenda addressed the responsibility of Governments in implementing national strategies and policies aided by the United Nations efforts to provide international cooperation to achieve the development and environmental objectives presented at Rio de Janeiro's conference (United Nations, 1992). It was a comprehensive plan of action that was adopted by more than 178 Governments (United Nations, 2020), in it there were many objectives of social and economic dimensions such as: combating poverty; promoting sustainable human settlement development and international cooperation to accelerate sustainable development in developing countries. Objectives for conservation and management of resources for development such as: protection of the atmosphere; combating deforestation; promoting sustainable agriculture and conservation of biological diversity. Objectives for strengthening the role of major groups, that touch on topics such as: global action for women towards equitable development; children and youth and the role of indigenous people (United Nations, 1992).

Following this 1992 Agenda the United Nations has had a continuum of conferences, in 2015 the United Nations general assembly presented the 2030 Agenda for Sustainable Development, described as a "*plan of action for people, planet and prosperity"* (United Nations, 2015). Following the lack of achievement of the Millennium Development Goals for 2015 that were established in 2000 at the Millennium Summit, the 2030 Agenda defines 17 Sustainable Development Goals comprised of 169 targets that balance the three dimensions of sustainable development, economic, social and environmental (United Nations, 2015).

These goals are the following:

1. End poverty in all its forms everywhere;
2. End hunger, achieve food security and improves nutrition and promote sustainable agriculture;
3. Ensure healthy lives and promote well-being for all at all ages;
4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all;
5. Achieve gender equality and empower all women and girls;

6. Ensure availability and sustainable management of water and sanitation for all;
7. Ensure access to affordable, reliable, sustainable and modern energy for all;
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all;
9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation;
10. Reduce inequality within and among countries;
11. Make cities and human settlements inclusive, safe, resilient and sustainable;
12. Ensure sustainable consumption and production patterns;
13. Take urgent action to combat climate change and its impacts;
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development;
15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss;
16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels;
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.

These goals have 169 targets that can be measured by one or more indicators, in specific regard to this report, goal number 11 refers to sustainability in cities and human settlements, it is associated with 10 targets, measured by 15 indicators presented in Table 1.

Table 1 - Sustainable Development Goal 11: Targets and Indicators (United Nations, 2015)

Targets	Indicators
11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	11.1.1 Proportion of urban population living in slums, informal settlements, or inadequate housing
11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities
11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 Ratio of land consumption rate to population growth rate
	11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and World Heritage Centre designation), level of government (national, regional and local/municipal), type of expenditure (operating

	expenditure/investment) and type of private funding (donations in kind, private non-profit sector and sponsorship)
11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	11.5.1 Number of deaths, missing persons and persons affected by disaster per 100,000 people
	11.5.2 Direct disaster economic loss in relation to global GDP, including disaster damage to critical infrastructure and disruption of basic services
11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1 Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated, by cities
	11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities
	11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months
11.A Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	11.A.1 Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs, by size of city
11.B By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels	11.B.1 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030
	11.B.2 Number of countries with national and local disaster risk reduction strategies
11.C Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	11.C.1 Proportion of financial support to the least developed countries that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings utilizing local materials

The International Organization for Standardization (ISO) is an independent, non-governmental international organization that give world-class specifications for products, services and systems (ISO, 2020). They publish international standards that range from several topics, it's *"ISO 37120 Sustainable Development for Communities"* standardizes indicators that regulate city services and quality of life. The ISO 37120 establishes indicators that measure and help guide a city's services and quality of life towards a sustainable development approach, it helps monitoring achievements towards sustainable development having the whole city system into consideration. Some indicators contributed to UN's 2030 Agenda and are present in both, such as environmental indicators as fine particulate matter concentration (PM2.5 and PM10) and others such as percentage of city population living in slums. In total, ISO 37120 presents 45 core indicators of sustainable development and over 50 supporting indicators regarding the next 19 topics (ISO 37120, 2018):

1. Economy
2. Education
3. Energy
4. Environment and climate change
5. Finance
6. Governance
7. Health
8. Housing
9. Population and social conditions
10. Recreation
11. Safety
12. Solid Waste
13. Sport and culture
14. Telecommunication
15. Transportation
16. Urban/local agriculture and food security
17. Urban planning
18. Wastewater
19. Water

The ISO organization published its *"ISO 37122 Sustainable cities and communities – Indicators for smart cities"* as a complementary standard to ISO 37120 establishing indicators with definitions and methodologies to measure their improvement in sustainable social, economic and environmental developments.

ISO 37122 (2019) defines a smart city as a city that "*increases the pace at which it provides social, economic, and environmental sustainability outcomes (…) use data information and modern technologies to deliver better services and quality of life to those in the city (…) without unfair disadvantage of others or degradation of the natural environment."*.

The objective of the standard is to help cities to identify indicators that help implement smart city policies, programmes and projects in order to (ISO 37122, 2019):

- respond to challenges such as climate change, rapid population growth, and political and economic instability by fundamentally improving how they engage society;
- apply collaborative leadership methods, work across disciplines and city systems;
- use data information and modern technologies to deliver better services and quality of life to those in the city (residents, businesses, visitors);
- provide a better life environment where smart policies, practices and technology are put to the service of citizens;
- achieve their sustainability and environmental goals in a more innovative way;

- identify the need for and benefits of smart infrastructure;
- facilitate innovation and growth;
- build a dynamic and innovative economy ready for the challenges of tomorrow.

In addition to ISO 37122's 50 "smart indicators", the ISO organization also published it's "*ISO 37123 Sustainable cities and communities — Indicators for resilient cities*" that establishes 60 indicators for resilience. The ISO defines a resilient city as one that has the capacity to survive, adapt and grow regardless of chronic stresses and acute shocks that it's individuals, communities, institutions, businesses, and systems might experience. This standard its major focus on disaster rick management and reduction as it is a major factor in the resilience of cities, although it does not exclude economic shocks, environmental stresses, and resource scarcity (ISO 37123, 2019).

Sustainability of cities has been a major concern of international organizations and governments, as previously mentioned the United Nations and ISO organization have worked together to provide a framework on which cities can guide themselves upon to create sustainable communities. The Sustainable Development Goals presented by the United Nations or 2030 have taken contributions of ISO 37120 and the complementary ISO 37122 and ISO 37123, providing indicator and targets that can be the best possible basis for the project.

2.2 Business Intelligence

Since early 1970s many forms of decision-support applications have emerged and Business Intelligence (BI) being one of them. The term was coined by Howard Dressner in the early 1990s, the time at which it was introduced as an umbrella term to describe analytical applications (Watson & Wixom, 2007), and so, BI can be described as a collection of decision support technologies that facilitates better and faster decisions to those whose job involves handling information in organizations (Chaudhuri et al., 2011).

In order to better understand the starting point of a BI project it is best to state that approximately 90% of the information an organization possesses is unstructured and only 10% is structured data (Rodrigues, 2012), that is gathered, transformed and presented by BI software typically available on the market (e.g. Data Warehouse, Dashboard and Data Mining software) as well as BI tools or applications which are products deployed in an organization for a particular purpose (Wieder & Ossimitz, 2015). The project takes advantage of a BI application that provides integrated data transformation, data warehouse and dashboard solutions.

Watson & Wixom (2007) describe the BI Framework process as having two primary activities "*…getting data in and getting data out*", the act of moving data from multiple data sources to an integrated Data Warehouse and the act of users developing analytics, based on this integrated Data Warehouse, in order to finally extract the full value of their data.

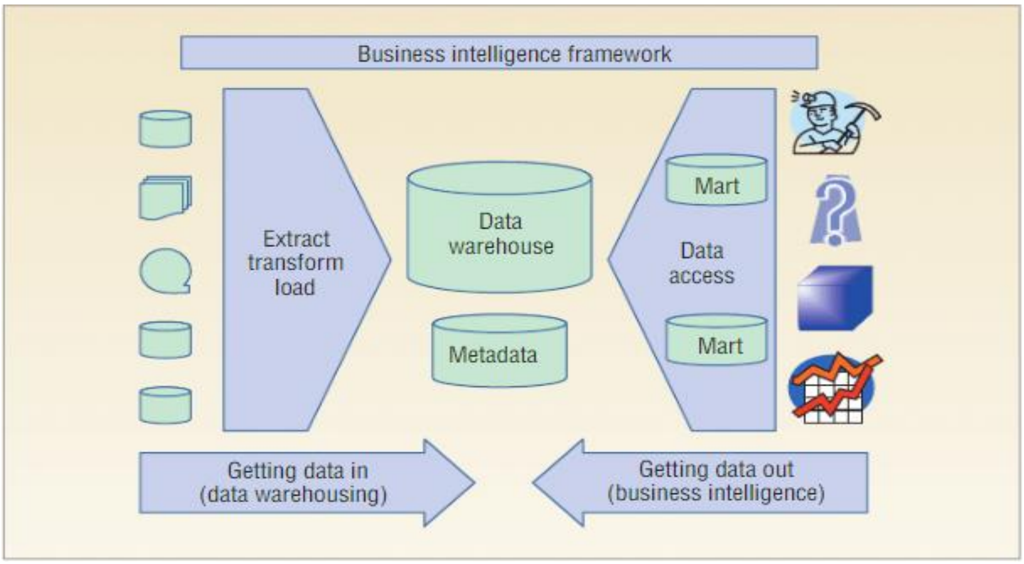


Figure 2 - Business Intelligence Framework (adopted from Watson & Wixom, 2007)

The process in order to create a BI solution starts by information being extracted from various information systems an organization holds, this information is then transformed into static data that is kept in a Data Warehouse. Then, BI gathers that data by using cubes, graphs, reports and other templates in order to convey useful information that can be transformed into insightful knowledge (Karlsen et al., 2012).

2.3 Key Performance Indicators

For a business to effectively measure their performance their measurements need to reflect their organizational context. This ensures that the specific decision support system that is in practice, creates value for the organization. Key Performance Indicators (KPI) are tools that can be used to measure the performance and success of a strategy (Karlsen et al., 2012).

A KPI is defined by being a strategically aligned metric, it measures the performance a business has against a defined goal. Eckerson (2009) identifies the goal to which a KPI is attached to as being multidimensional, as shown in Figure 3, having a time frame to which they must be achieved, a benchmark to where they are compared to, a strategically defined target they must achieve, and encodings in software that enable the visual display of performance.

Strategy	KPIs embody a strategic objective.
Targets	KPIs measure performance against specific targets. Targets are defined in strategic, planning, or budget sessions and can take different forms (e.g., achievement, reduction, absolute, zero).
Ranges	Targets have ranges of performance (e.g., above, on, or below target).
Encodings	Ranges are encoded in software, enabling the visual display of performance (e.g., green, yellow, red). Encodings can be based on percentages or more complex rules.
Time frames	Targets are assigned time frames by which they must be accomplished. A time frame is often divided into smaller intervals to provide mileposts of performance along the way.
Benchmarks	Targets are measured against a baseline or benchmark. The previous year's results often serve as a benchmark, but arbitrary numbers or external benchmarks may also be used.

Figure 3 - Elements of a KPI (adopted from Eckerson, 2009)

The decision to define which processes in an organization should be measured can be difficult, therefore it is important that people with enough knowledge of the organization make these decisions (Beatham et al.,2004). The targets are usually set during collective strategic planning to ensure they are accurate in measuring the performance of the strategic objectives.

Targets are an important part of a KPI definition, as such it is important to identify the different types of targets a KPI can be associated with.

Eckerson (2009) identifies five types of targets:

1. Achievement: performance should reach the target or go over the target.
2. Reduction: performance should reach or be lower than the target.
3. Absolute: performance should be equal to the target, not above or below.
4. Min /max: performance should be between a range of values, any values outside this range are not good.
5. Zero: performance should equal zero, being the minimum value possible.

Eckerson (2009) also identifies ten characteristics of a KPI that make it more likely to have a high impact on the business of an organizations:

1. Sparse: fewer KPIs is better.
2. Drillable: having the ability to drill into detail.
3. Simple: easy to understand KPIs.
4. Actionable: user know how to act to affect outcome
5. Owned: KPIs have an owner.
6. Referenced: users can view origins and context.
7. Correlated: KPIs drive desired outcomes
8. Balanced: KPIs consist of both financial and non-financial metrics
9. Aligned: KPIs don't undermine each other.
10. Validated: Workers can't circumvent KPIs.

2.4 Dashboard Development and Information Visualization

In order to provide a clear analysis through visual information that a Business Intelligence solution wants to convey to its final user, it is necessary to gather some inputs on Information Visualization and Dashboard Development.

A dashboard contains visual information about performance metrics that enables users to monitor and manage their KPIs and progress towards an objective. It is a part of a subset of powerful tools and components that give users the ability to identify problems and opportunities, act and adjust plans according to their specific objectives (Eckerson, 2009).

Few (2006) defines a dashboard as *"…a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance".*

Following this definition, the points to take from it are that a dashboard is presented visually, as a combination of both text and graphics. Being highly graphical it can communicate efficiently if it is designed correctly in a way that the human eye can gather the most important and correct information from it.

A dashboard displays the information needed to achieve specific objectives, meaning a dashboard should carry a collection of information, often not otherwise related that can come from different sources related to different business functions.

It should fit on a single screen so it can all be seen at once, "*at a glance*", its point is to have the most important information readily and effortlessly available. In a well-designed dashboard, if there is a need to act the dashboard should give its user that alert, the information is clear, simple, summarized and insightful. It should give the user the option to drill down into detailed information if it should be required to take action upon the initial information (Few, 2006).

A dashboard has a tremendous power of visual perception to communicate, according to Few (2006), but in order to be efficient those who implement them must have some understanding of visual perception, the way people see and think. A dashboard is a powerful tool, but it must be well designed to achieve its potential.

To be successful a dashboard must a be organized, the data should be thoughtfully displayed. Users should be able to gather information in a meaningful and efficient manner, and for that, the dashboard must indicate to the user what is important by appearing larger and more visually prominent, if there is an order to the information displayed, the arrangement of the dashboard should follow that sequence of visual attention, related items should be positioned close to one another so the users can change their attention between information but still gather insight (Few, 2007).

Most dashboards have poorly designed implementations; this makes it fail in its purpose to communicate efficiently and effectively. When the implementation is adequately carried out dashboard can provide a unique and powerful means to present information and facilitate data interpretation (Few, 2006).

Few (2006) identifies the most common errors in dashboard design that must be avoided:

- Exceeding the boundaries of a single screen,
- Supplying inadequate context for the data;
- Displaying excessive details or precision;
- Choosing a deficient measure;
- Choosing inappropriate display media;
- Introducing meaningless variety;
- Using poorly designed display media;
- Encoding quantities data inaccurately;
- Arranging the data poorly;
- Highlighting important data ineffectively or not at all;
- Cluttering the display with useless decoration;
- Misusing or overusing colour;
- Designing an unattractive visual display.

3. CONCEPTUAL MODEL

3.1 Indicators and Measures

As previously stated in the literature review, the sustainability of a city can be measured by an extensive list of indicators that stem from several urban management areas. The identified Sustainability Development Goals of United Nations indicate 17 goals, of which, number 11 refers to making cities and human settlements inclusive, safe, resilient, and sustainable. For this goal there are 10 targets with 15 indicators to measure these targets.

Figure 4 - SDG number 11

Beyond these indicators there are ISO's standards for sustainability compiling a very extensive role of indicators that have also been previously mentioned.

In practice, the project's goal of developing a sustainability indicator dashboard for Lisbon is going to be based on open source data, possibly provided by more than one public or private organization and as such the selection of indicators is constrained by the availability and quality of the data produced by these source organizations, meaning, of all the indicators considered previously, only the ones that are of significant importance and measurable for the metropolitan area of Lisbon, but most of all, available, will be selected. Furthermore, since some indicators may not be available, a close substitute regarding the same topic may be chosen in order to have some data on the same field of topic.

For the development of the dashboard a selective process of the topics of indicators must be made when considering keeping the dashboard clear, simple, summarized and insightful (Few, 2006). Avoiding excessive detail and displaying an excessive number of indicators is key to making the dashboard's information perceivable, this selection is also affected by the scarcity of proper indicators to evaluate performance of the topic.

Taking ISO 37120 into consideration, the following topics were evaluated for obtainability:

Table 2 - Topics of areas of sustainability

Topic	*Number Core Indicators*	*Number Supporting Indicators*
Environment and climate change	3	6
Economy	1	7
Population and social conditions	1	2
Education	4	2
Energy	5	2
Health	4	2
Safety	5	5
Solid waste	5	5
Wastewater	3	1

When considering ISO´s indicators for community's and city's sustainability the classification of core indicator and supporting indicator was taken into account when a substitute indicator was needed. To avoid excessive information when developing the dashboard, core indicators were considered of higher importance. In the absence of the exact calculation method or format described in the document consulted the closest available substitute to give insight to the same topic was considered. An indicator was classified as a substitute when the metric was significantly different, but it gave some insight to the original fact the indicator was measuring.

Most of the indicators are sourced from Instituto Nacional de Estatística (INE), a public institute that gathers and produces statistics about several areas of Portugal´s population, society, territory, economy and so forth. Acting as the official public central hub for statistics coming from varied other Portuguese public and private institutes, their internet portal revealed itself to be the fastest and most complete source of data to meet the project's demands.

Indicators regarding air quality are retrieved from Agência Portuguesa do Ambiente's website.

All indicators are detailed over an identified time period and have a defined update interval that indicates the regularity of data updates.

For simplicity, and considering the number of indicators obtained, the Economy and Population and Social Conditions topics were consolidated into the Economy and Social Conditions (ESC) topic, as well as the Solid Waste and Wastewater topics were consolidated into the Waste and Wastewater Management (WWM) topic. Furthermore, to better describe the retrieved indicators, the Environment and climate change topic is indicated as Air Quality and Environment (AQE) topic.

The following tables describe the indicators that were retrieved, as well as their source, time interval between updates and type (core; supporting; substitute):

Table 3 - Air Quality and Environment Indicators

Indicator	*Source*	*Update Interval*	*Type*
Fine particulate matter (PM2.5) concentration	Agência Portuguesa do Ambiente	Hourly	Core Indicator
Particulate matter (PM10) concentration	Agência Portuguesa do Ambiente	Hourly	Core Indicator
NO2 (nitrogen dioxide) concentration	Agência Portuguesa do Ambiente	Hourly	Supporting Indicator
SO2 (sulfur dioxide) concentration	Agência Portuguesa do Ambiente	Hourly	Supporting Indicator
O3 (ozone) concentration	Agência Portuguesa do Ambiente	Hourly	Supporting Indicator
Carbon Monoxide (mg/m3)	Agência Portuguesa do Ambiente	Hourly	Substitute Indicator
Percentage of city land area by land use and cover	INE	Annual	Substitute Indicator

Table 4 - Economy and Social Conditions Indicators

Indicator	*Source*	*Update Interval*	*Type*
City’s Unemployment Rate	INE	Annual	Core Indicator
Youth unemployment rate	INE	Annual	Supporting Indicator
Number of new patents per 100 000 population per year	INE	Annual	Supporting Indicator
Gini coefficient of inequality	INE	Annual	Supporting Indicator
Resident population at-risk-of poverty or social exclusion	INE	Annual	Substitute Indicator
Survival rate (%) of Enterprises born 2 years before	INE	Annual	Substitute Indicator

Table 5 - Economy Profile Indicators

Indicator	*Source*	*Update Interval*	*Type*
Average household income (profile indicator)	INE	Annual	Profile Indicator
Annual inflation rate based on the average of the past five years (profile indicator)	INE	Annual	Profile Indicator
City product per capita (profile indicator)	INE	Annual	Profile Indicator

Table 6 - Education Indicators

Indicator	*Source*	*Update Interval*	*Format*
Percentage of students completing primary education: survival rate	INE	Annual	Core Indicator
Percentage of students completing secondary education: survival rate	INE	Annual	Core Indicator
Primary education student–teacher ratio	INE	Annual	Core Indicator
Students enrolled in tertiary education by sex	INE	Annual	Substitute Indicator
Graduates of tertiary education per 1000 inhabitants (No.) of resident population aged between 20 and 29 years old	INE	Annual	Substitute Indicator
Average number of students enrolled in non-tertiary education by computer connected to the internet (No.)	INE	Annual	Substitute Indicator

Table 7 - Energy Indicators

Indicator	*Source*	*Update Interval*	*Type*
Consumption of electric energy by inhabitant (kWh/ inhab.)	INE	Annual	Substitute Indicator
Household consumption of electric energy by consumer (kWh/ cons.)	INE	Annual	Substitute Indicator

Consumption of natural gas per 1000 inhabitants (Nm^3)	INE	Annual	Substitute Indicator
Percentage Electric consumption of public buildings (kwH)	INE	Annual	Substitute Indicator
Percentage Electric consumption of public street lighting (kwH)	INE	Annual	Substitute Indicator

Table 8 - Waste and Wastewater Management Indicators

Indicator	*Source*	*Update Interval*	*Type*
Total collected solid waste per capita	INE	Annual	Core Indicator
Percentage of city's urban waste that is recycled and reused	INE	Annual	Core Indicator
Percentage of city's solid waste that is disposed of in sanitary landfill	INE	Annual	Core Indicator
Percentage of city's solid waste that is used for energy recovery	INE	Annual	Substitute Indicator
Quality index of bulky wastewater sanitation services (%)	INE	Annual	Substitute Indicator
Percentage of tertiary level treated wastewater	INE	Annual	Substitute Indicator

Table 9 - Health Indicators

Indicator	*Source*	*Update Interval*	*Type*
Average life expectancy	INE	Annual	Core Indicator
Number of in-patient hospital beds per 100 000 population	INE	Annual	Core Indicator
Under age five mortality per 1 000 live births	INE	Annual	Core Indicator
Suicide rate per 100 000 population	INE	Annual	Supporting Indicator
Mortality rate due to some infectious and parasitic diseases per 100 000 inhabitants	INE	Annual	Substitute Indicator

Table 10 - Safety Indicators

Indicator	*Source*	*Update Interval*	*Type*
Number of firefighters per 100 000 population	INE	Annual	Core Indicator
Number of homicides per 100 000 population	INE	Annual	Core Indicator
Crime rate (‰) per 1000 inhab.	INE	Annual	Substitute Indicator
Fire brigades (No.) per 100.000 population	INE	Annual	Substitute Indicator

In total, 39 indicators were obtained plus 3 economy profile indicators. Table 11 indicates for core and supporting indicators, the number of obtained over total number of indicators evaluated and the percentage of total indicators that were successfully retrieved.

Table 11 - Number of obtained indicators

Topic	*Core Indicators*	*Supporting Indicators*	*% Obtained Indicators*	*Substitute Indicators*
Air Quality and Environment	2/3	3/6	56%	2
Economy and Social Conditions	1/2	3/9	36%	2
Education	3/4	0/2	50%	3
Energy	0/5	0/2	0%	5
Waste and Wastewater Management	3/8	0/6	21%	3
Health	3/4	1/2	67%	1
Safety	2/5	0/5	20%	2
Total indicators	14/31	7/32	33%	18

When only considering core and supporting indicators for these topics, only 21 of 63 indicators, representing 33% of indicators, were successfully retrieved from the open-source databases available. When substitute indicators are considered the percentage raises to 62%.

Additionally, to the mentioned indicators, supporting data must be retrieved to achieve some desired indicators. Data for Resident Population by year is necessary to perform calculations for indicators over population numbers where the original data cannot be retrieved as the desired measure.

Furthermore, to provide a cleared view of the data and a better understanding of the information given by each indicator, some measures should be created.

For air quality indicators, such as the Level of Particulate Matter 10, that register data values for each hour of a full year, an average value measure should be calculated. This provides a more comprehensive meaning to data over whichever desired time granularity it may be displayed, and it should be clear to the user that the values seen are hourly averages for each indicator.

To add performance analysis, comparative measures should be created. All indicators are observed over a time period and can be benchmarked over each previously observed data point. For most indicators this implies measures comparing evolution from the previous years value, where positive variations could either imply a positive or negative effect on sustainability based on each indicator’s significance. Furthermore, each measure should consider the original indicator’s value when created, meaning, absolute values and ratios should be comparable over a percentage or an absolute variation measure, while percentage indicators should be comparable by their percentual points variation over previous observations.

3.2 Data Model and Structure

A BI solution would traditionally be implemented over a structured Data Warehouse were data would be treated and integrated over from one or more data sources, this information could then be accessed by users over an analysis program like Microsoft's Power BI to develop dashboards and reports. In this project the suggested data for the dashboard does not origin from a structured data warehouse but instead consists of individual, unrelated, unstructured indicators for a city with a time granularity.

To manage the data, a simple relational model that structures indicators over different tables must be implemented. Each table will merge indicators over matching time granularity and location, which will then serve to provide relations between each created table.

A requirement of this model structure is a separate date table, identified as the Date Dimension. This will allow the model to relate and analyse indicators over time more effectively, ensuring an organized and simpler navigation over the model's data as well as provide the necessary relationships to create measures regarding evolution of indicators over time.

A second dimension to the model is the Location Dimension that identifies from which location the indicators and recorded date is originated.

Identifying each topic of area of sustainability, a factual table will be created which in turn will be related to both described dimensions by a generated matching key. In the case of the topic of Air Quality and Environment, two separate tables will be created due to differences in time granularity from the air quality indicators to the land usage indicators.

Figure 5 exemplifies the conceptual model structure with two dimensions serving eight factual tables.

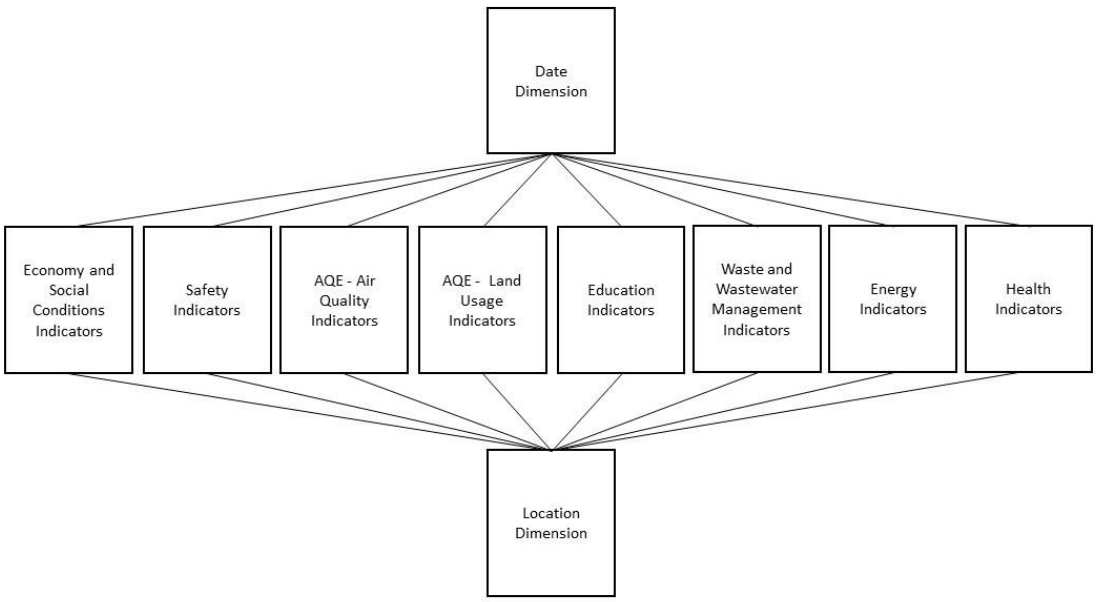


Figure 5 - Conceptual Model Structure

3.3 Dashboard Model

The conceptual model of the dashboard is developed to maximize the visualization of the most important information without displaying excessive detail or meaningless variety. An initial dashboard page that presents readily and effortlessly the most important information available, as indicated in the literature review, gives the user a quick overview of indicator performance over each area of sustainability.

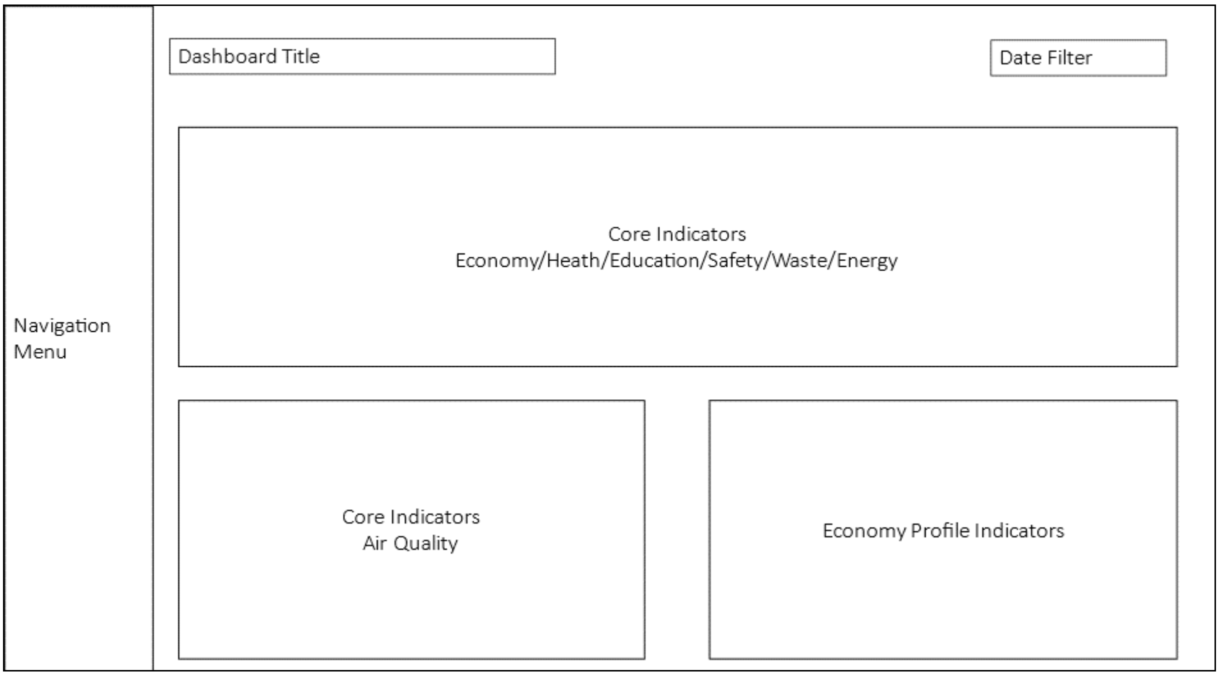


Figure 6 - Overview Dashboard Page

On the Overview Page only Core and Profile Indicators are presented to maximize simplicity and readability while giving context. Air Quality core indicators are display separately from the upper section of core indicators of the remaining topics for better space management, occupying a left centre space on the page. To the bottom right corner, a graphical display of Economy Profile indicators over time are presented, giving context to the city's economic reality. For data navigation a date filter is provided for the user.

Giving more insight and detail to each area of sustainability can be obtained by a lateral navigation menu, that links to a dedicated dashboard page regarding the selected topic but maintaining a view of core indicators for most areas as to provide context information.

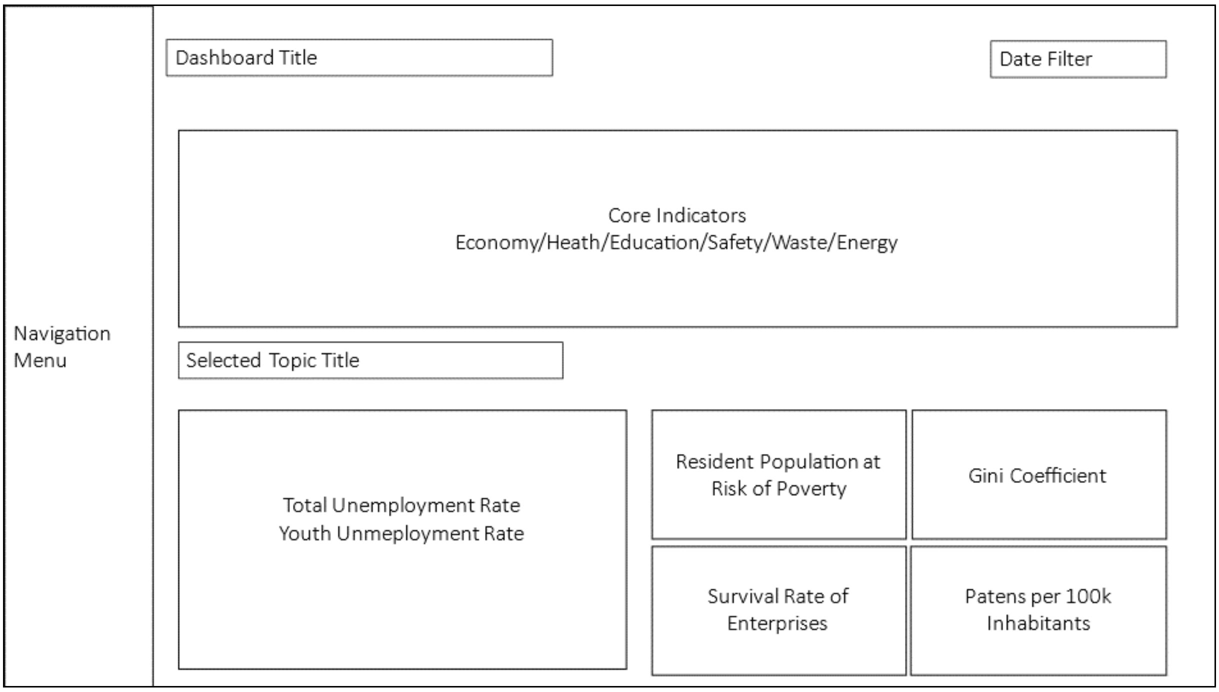


Figure 7 - Economy and Social Conditions Indicators Dashboard Page

For the Economy and Social Conditions Page core indicators for most areas of sustainability are displayed over the upper centre space of the page, maintaining the same visuals as in the Overview Page for coherence. This display will stay true for all subsequent topic related pages, while the only change over topic pages will be the lower spacing of the page that presents all the respective indicators in a more detailed visual manner, giving the user a more insightful view of each topic.

Total Unemployment Rate and Youth Unemployment Rate occupy the lower left space with a more prominent graphical display of both indicators, for easier comparison visualisation.

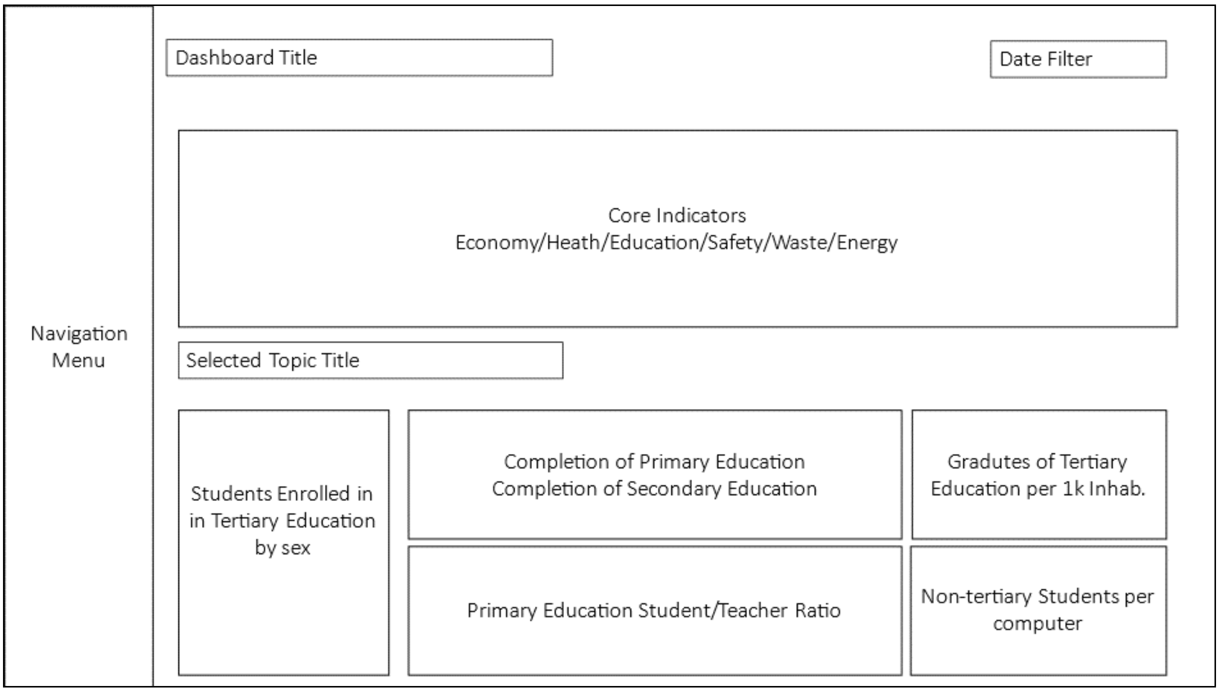


Figure 8 - Education Indicators Dashboard Page

For the Education Indicators page, occupying most space is both indicators of Completion of Primary and Secondary Education at centre, represented in the same graphical space for better comparison between both indicators.

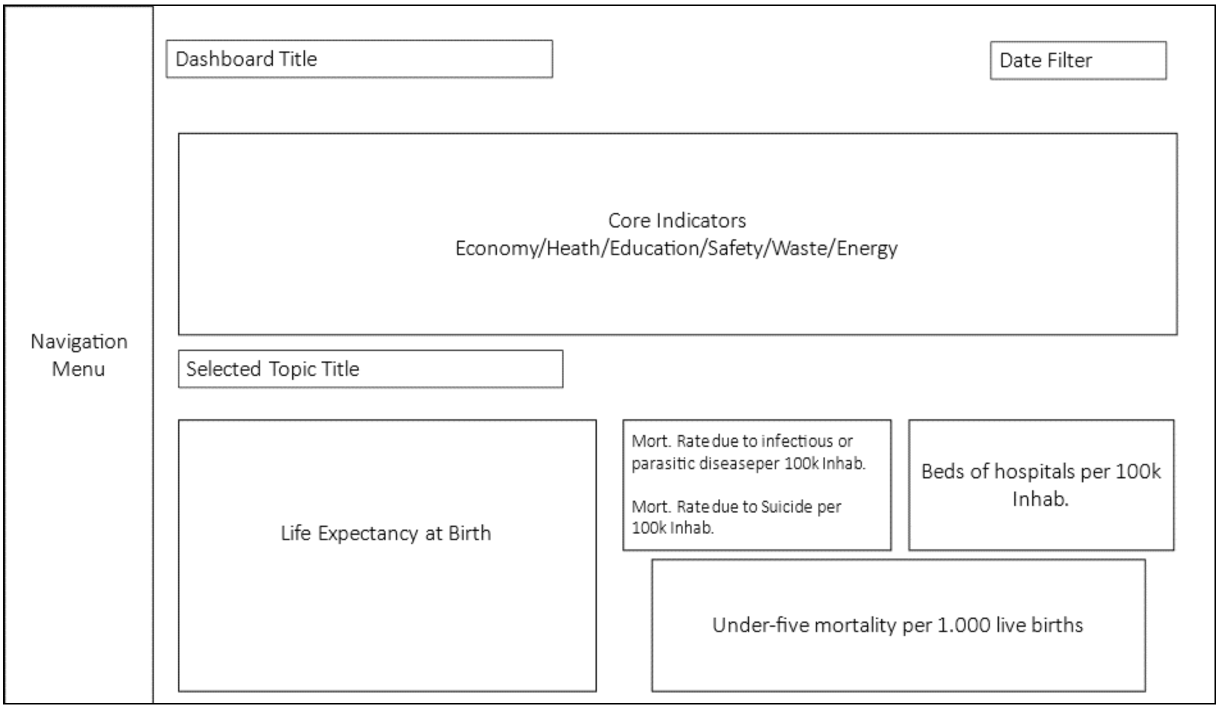


Figure 9 - Health Indicators Dashboard Page

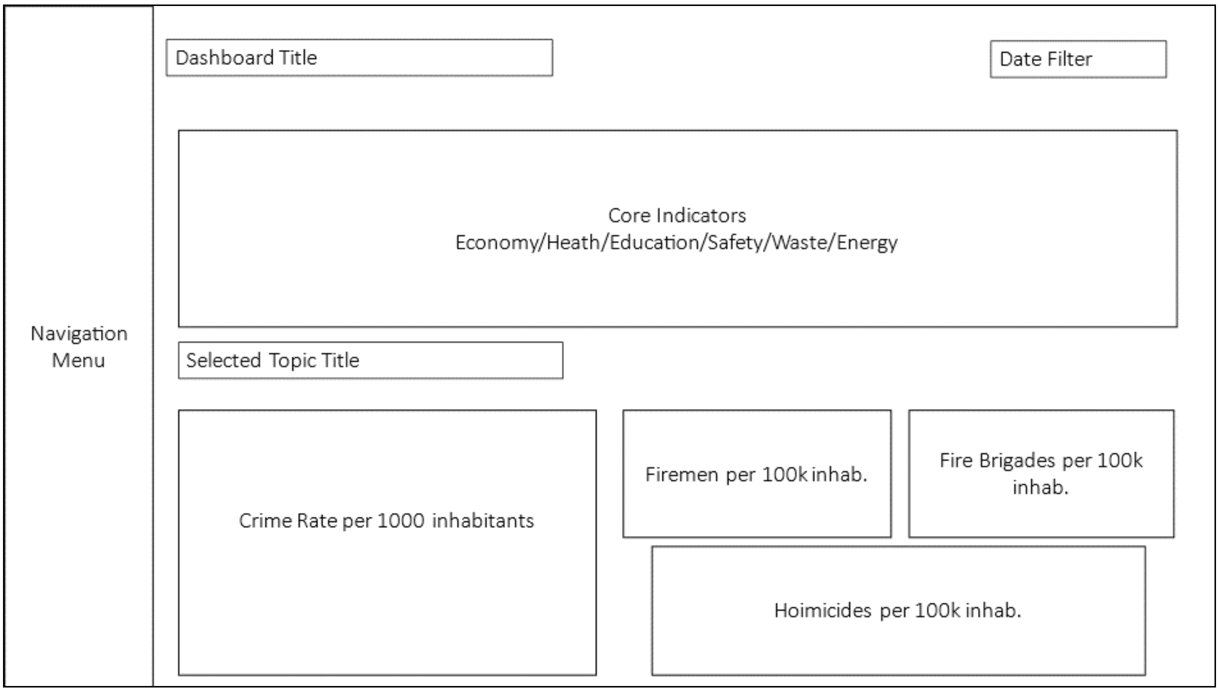


Figure 10 - Safety Indicators Dashboard Page

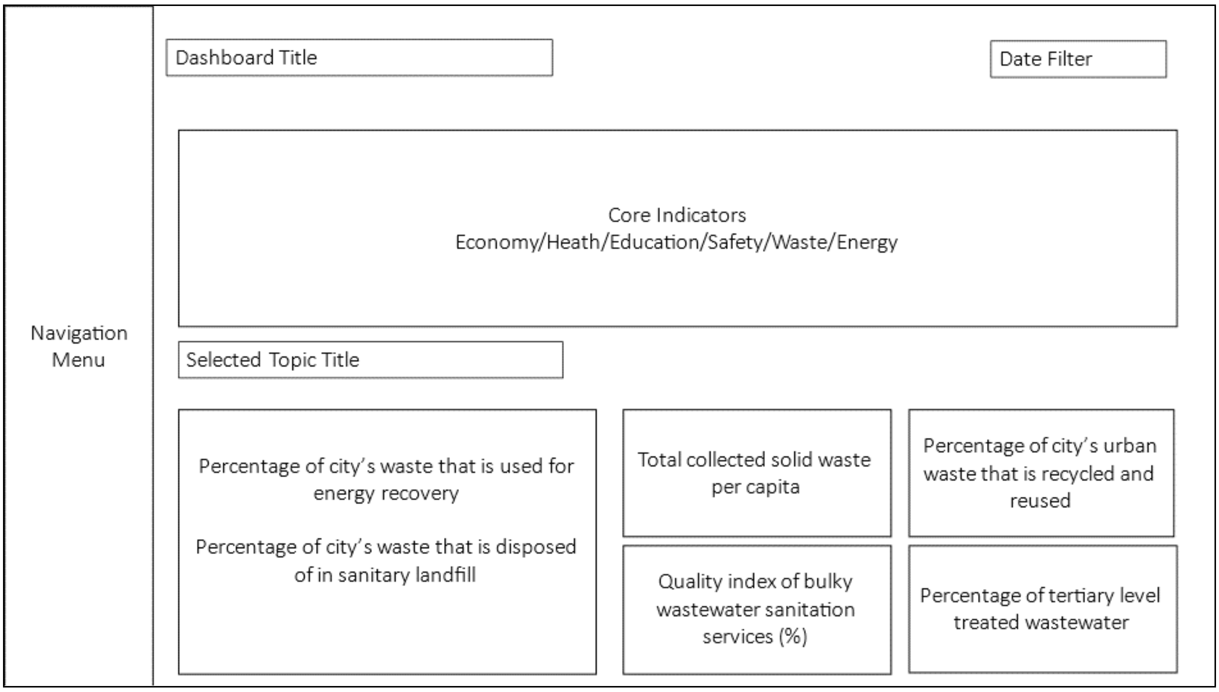


Figure 11 - Waste and Wastewater Management Indicators Dashboard Page

Regarding WWM page's lower left space displays percentage of the city's waste that is use for energy recovery and that is disposed in sanitary landfills, by nature these indicators would be part of a zero to one-hundred percentage graph.

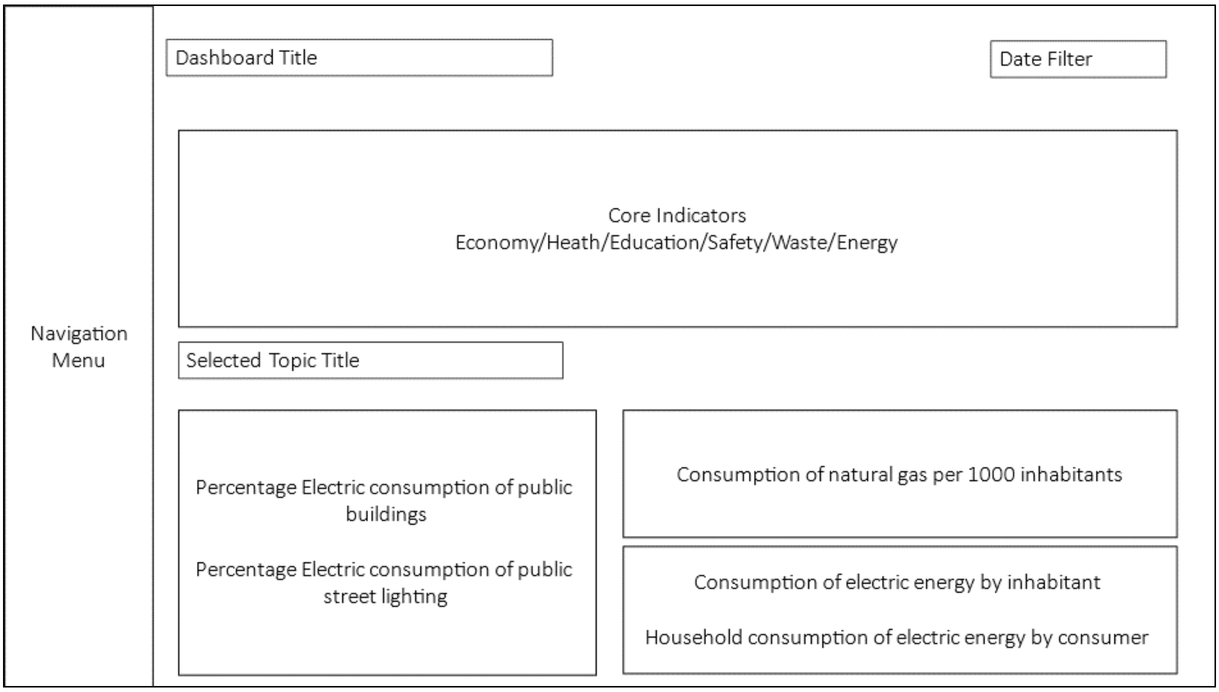


Figure 12 - Energy Indicators Dashboard Page

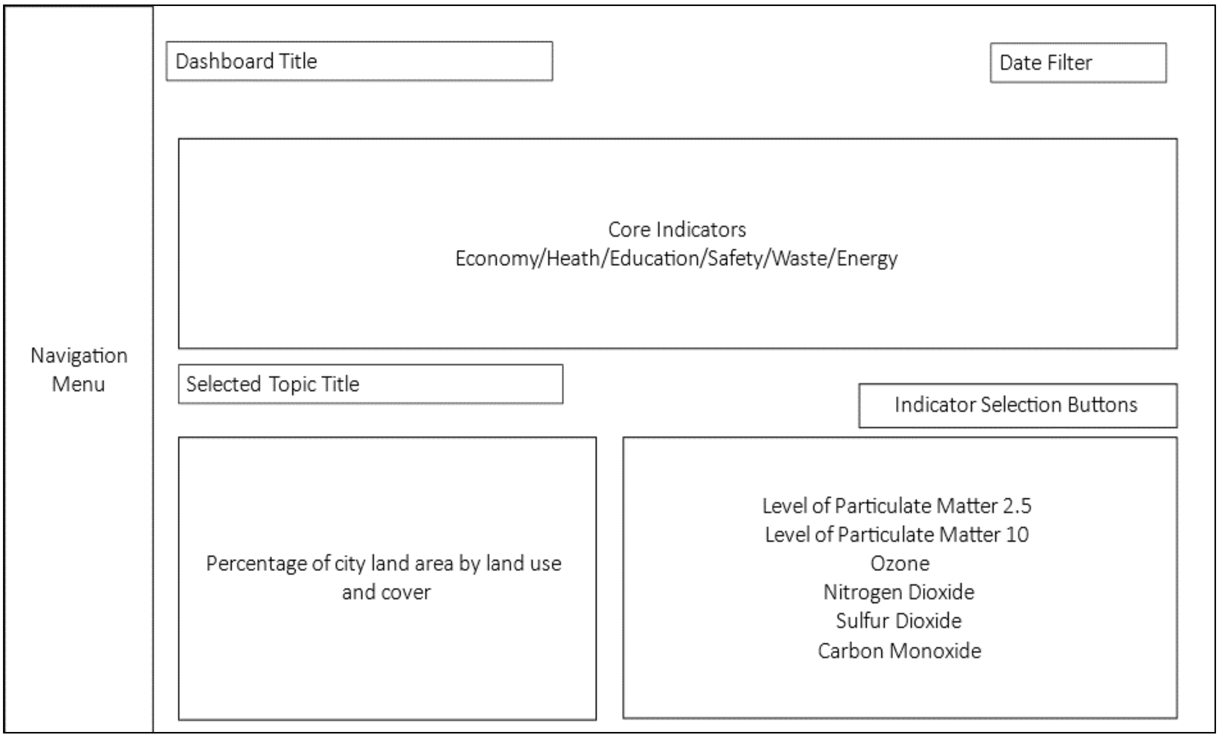


Figure 13 - Air Quality and Environment Indicators Dashboard Page

At the bottom left of AQE Indicator’s page all indicators for air quality are displayed graphically and a selection button for each indicator is provided at the top of the display. These selection buttons give the user a clearer view of each air quality indicator’s performance, for when selected, the display below only focuses on the desired indicator omitting the remaining data.

4 DEVELOPMENT

4.1 Dashboard Development Tool

The project's base for the dashboard development will be Microsoft's Power BI since Microsoft was considered in 2020 a leader in Analytics and Business Intelligence Platforms for 13 consecutive years by Gartner. Microsoft got the highest classification in "Completeness of Vision" as well as in "Ability to Execute" in relation to other vendors that were evaluated in this report. The only other vendor to come close to Microsoft's classification was Tableu. Power BI with the focus on visual-based data discovery, interactive dashboards, data preparation and augmented analytics is a strong choice for a dashboard development project (Richardson et al., 2020).

Figure 14 - Magic Quadrant for Analytics and Business Intelligence (Richardson et al., 2020)

4.2 Data Extraction

For most indicators, a single data file was created, all indicators sourced from INE had to be obtained through searching and downloading the data files from the data portal. Other options to obtain data were available (e.g. API connection), but the process revealed itself to not meet the desired structure for historical data.

The INE data portal requires adjustments in the selection conditions of the dimensions available to obtain the desired table of data.

All indicators contained a “Data Reference Period” and a “Place of Residence” dimension. For the “Data Reference Period” dimension every available selection was considered. This means that if an indicator is created annually then the display is a record of data for each year there is recorded data. The “Place of Residence” dimension was always only selected as “Área Metropolitana de Lisboa” this slices the data to only display information for Lisbon’s metropolitan area.

Aside from the two dimensions mentioned above some indicators had additional characteristics (e.g. sex, education level) that required additional adjustments to obtain the desired display of data for Lisbon’s metropolitan area by time, being the desired display the first column as the “Data Reference Period” and subsequent columns the indicator’s measure. After these adjustments were made to the consultation, the INE portal provides a download CSV file (Figure 15) option that was used to obtain the configured tables as data to be imported to Power BI.

```
Statistical table extracted on August 28, 2020 (12:49:15);
http://www.ine.pt;
;
;
;
Data reference period;Household consumption of electric energy by consumer (kWh/ cons.) by Geographic localization (NUTS - 2013) -  Annual
;Geographic localization (NUTS - 2013) (1)
;17: Área Metropolitana de Lisboa
;kWh/ cons.
2018;2220.5
2017;2094.9
2016;2159.5
2015;2142.4
2014;2167.5
2013;2195.3
2012;2299.9
2011;2454.2
;
Household consumption of electric energy by consumer (kWh/ cons.) by Geographic localization (NUTS - 2013) -  Annual - DGEG, Statistics on coal, oil, electric power and
natural gas;
;
Note(s):;
"(1) From January 1, 2015 came into force a new version of NUTS (NUTS 2013). At NUTS II level was just a name change in ""Lisboa"" which became known as ""Área Metropolitana
de Lisboa"".";
;
;
;
This data last updated:june 22, 2020;
;
;
Table Metadata;
;
Household consumption of electric energy by consumer (kWh/ cons.);
Name;Household consumption of electric energy by consumer (kWh/ cons.) by Geographic localization (NUTS - 2013) -  Annual
Regularity;Annual
Source;DGEG, Statistics on coal, oil, electric power and natural gas
First available period;2011
Last available period;2018
Dimensions;
     Dimension 1;Data reference period
     Dimension 2;Geographic localization (NUTS - 2013)
Concepts;
     ELECTRIC ENERGY;Energy produced by hydroelectric, conventional thermal, nuclear, wave and tidal, wind and solar photovoltaic power plants.
     REFERENCE PERIOD;The length of time for which data are collected, e.g. a specific day, month or year.
Definition;
Formule;
Measure unit (symbol);Kilowatt hour/ Consumer (kWh/ cons.)
Power of 10;0
Last update date;22/jun/20
```

Figure 15 - CSV file example from Instituto Nacional de Estatística

The air quality indicators sourced from Agência Portuguesa do Ambiente’s portal were downloaded in excel datasheet format (Figure 16). An individual file was downloaded for each year of existing recorded data. The data is measured from Entrecampos’s station. Lisbon’s municipality has a total of six stations available in this data portal that gather air quality indicators, Entrecampos station was chosen not only for its central geographical location but for the completion of data recorded relatively to other stations.

Entrecampos	Dióxido de Enxofre (µg/m3)	Partículas < 10 µm (µg/m3)	Ozono (µg/m3)	Dióxido de Azoto (µg/m3)	Monóxido de Carbono (mg/m3)	Benzeno (µg/m3)	Partículas < 2.5 µm (µg/m3)
2018-01-01 00:00:00	0,4	52,9	9	69,5	0,612	1,7	21,6
2018-01-01 01:00:00	0,1	57,1	2	72,2	0,676	2,2	24,7
2018-01-01 02:00:00	0,1	56,8	1	69,2	0,67	1,8	26,5
2018-01-01 03:00:00	0,1	54,7	1	69,8	0,896	2,3	38,1
2018-01-01 04:00:00	0	56,5	1	66,6	0,934	3	39
2018-01-01 05:00:00	0	68,9	1	59,4	0,769	2,9	44,8
2018-01-01 06:00:00	0	68,9	0	54,8	0,719	2,3	44,4
2018-01-01 07:00:00	0	69	1	54,8	0,919	2,7	42
2018-01-01 08:00:00	0	66,2	1	55,8	0,832	2,4	42
2018-01-01 09:00:00	0	49,7	3	61,3	0,902	2,7	42,2
2018-01-01 10:00:00	0	48	11	69,6	0,815	2,8	39,9
2018-01-01 11:00:00	0	37,1	53	28,2	0,293	1,4	25,2
2018-01-01 12:00:00	1,5	35,6	63	22,8	0,276	0,5	23,7
2018-01-01 13:00:00	1,6	25,9	65	21,7	0,226	0,6	14,1
2018-01-01 14:00:00	2,1	25,3	71	14,6	0,2	0,4	14,6
2018-01-01 15:00:00	2	22,1	71	15,9	0,203	0,4	18,4
2018-01-01 16:00:00	2,2	22,6	67	20,2	0,218	0,4	17,7
2018-01-01 17:00:00	2,1	25	35	54,2	0,313	0,6	13,7
2018-01-01 18:00:00	2	26,5	16	75	0,4	0,9	14
2018-01-01 19:00:00	1,9	36,4	8	82,6	0,484	1,2	15,8
2018-01-01 20:00:00	2	37,7	1	96,5	0,8	1,9	16,6
2018-01-01 21:00:00	2	46	1	92,8	0,98	3,1	21,6
2018-01-01 22:00:00	2,5	47	1	91,4	1,073	3,4	23,1
2018-01-01 23:00:00	2,4	53,1	1	86,3	1,169	3,7	32,9

Figure 16 - Data from Agência Portuguesa do Ambiente

For data regarding the Location Dimension, a CSV file was created as a data source and subsequently imported through Power BI’s Power Query. Since the project focuses on data generated by a city’s activity, the Location Dimension should consider a granularity up to the description of city name. The CSV file was created with three columns: LocationKey, City and Country. The LocationKey column is the unique identifier of each location.

4.3 Data Transformation

For most data sources a form of data transformation and cleaning must be done before any analysis can be considered. The objective of data transformation is to transform what was otherwise uninformative or useless data into clear and useful information. As shown in the previous chapter, the data sources included unwanted data as well as unwanted formatting.

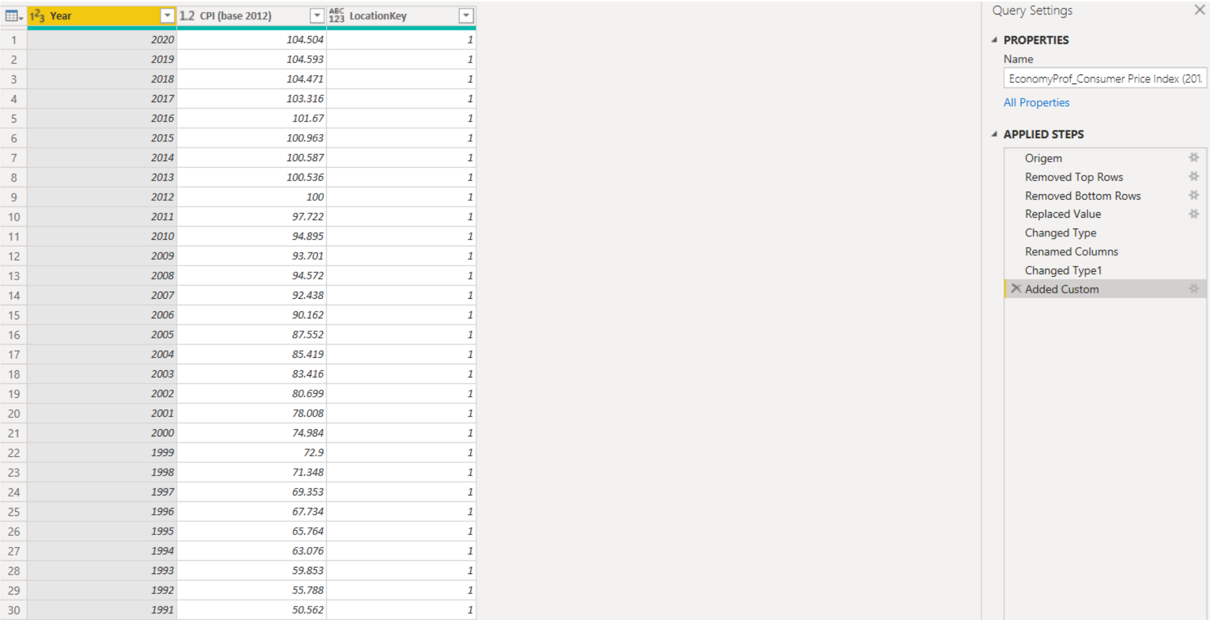
Transformations had to be made to the extracted data, for every indicator sourced from INE. Using Power BI’s “Power Query” tool, the extracted data files were imported to Power BI as queries and necessary adjustments were made to clean and create new data.

Most CSV files that were extracted contained metadata that was removed by eliminating rows that were unnecessary, only leaving the necessary data to form the tables. Once only the desired data was selected, adjustments to the values were made accordingly to what was expected while keeping the source information intact, undesired characters were replaced and column data type was changed accordingly.

Since no data had a column for location identification an additional column was created with the location key that would identify Lisbon. Finally, descriptive columns names were attributed to each existing column.

For most indicators the previously mentioned transformations were sufficient while some indicators required additional calculated columns created from the source data. Such is the case of the indicator for Percentage of Tertiary Level Treated Wastewater, where the total value of treated water in m^3 was not in the original data source. As such this column was created to provide a base to calculate the required measure in subsequent steps of development.

Figure 17 shows to the right, the applied transformations to the source data of the Consumer Price Index indicator and the final product as a table.



	Year	CPI (base 2012)	LocationKey
1	2020	104.504	1
2	2019	104.593	1
3	2018	104.471	1
4	2017	103.316	1
5	2016	101.67	1
6	2015	100.963	1
7	2014	100.587	1
8	2013	100.536	1
9	2012	100	1
10	2011	97.722	1
11	2010	94.895	1
12	2009	93.701	1
13	2008	94.572	1
14	2007	92.438	1
15	2006	90.162	1
16	2005	87.552	1
17	2004	85.419	1
18	2003	83.416	1
19	2002	80.699	1
20	2001	78.008	1
21	2000	74.984	1
22	1999	72.9	1
23	1998	71.348	1
24	1997	69.353	1
25	1996	67.734	1
26	1995	65.764	1
27	1994	63.076	1
28	1993	59.853	1
29	1992	55.788	1
30	1991	50.562	1

Figure 17 - Consumer Price Index Data Transformation

For data regarding air quality provided by Agência Portuguesa do Ambiente, fewer transformations were required as the source data was already organized and did not contain any metadata that needed to be eliminated. For these sources only columns names were attributed, a location key column added and column data types changed.

For better organization, each query related to a specific topic was grouped in Power BI's Power Query Editor by topic.

Once all queries were transformed and were in their final form, merging the queries was needed to create the final indicator tables for each topic of sustainability. For most indicators the *Year* column and the *LocationKey* column were used to merge queries, matching values and adding all data from both tables (full outer join).

This method of merging requires subsequent transformations to the data since with every merged query duplicates for *Year* and *LocationKey* columns were present. To remove these duplicate columns a conditional column step was added after each merging query.

Having "Year1" and "Year2" as both columns from merged queries "Query1" and "Query2", the new conditional column is created by specifying that when "Year1" equals "*null*" value, the value that should be considered is the value from "Year2", else, the value should remain as "Year1"'s original value. Both original columns are then deleted and the remaining column for *Year* should have no *"null"* value. The same logic was applied to unify the *LocationKey* column data.

Figure 18 exemplifies the steps when merging queries to form the final tables.

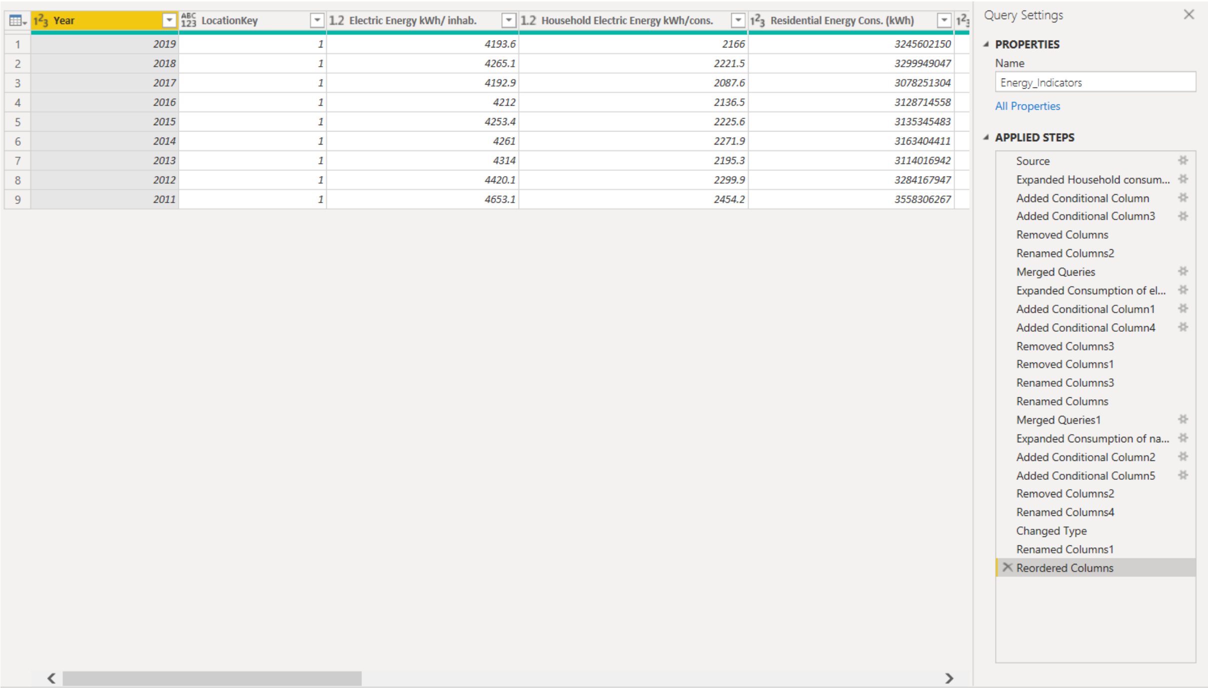


Figure 18 - Transformations for Energy Indicators query

Presented in Figure 19 are the final queries, where 46 queries were created in total.

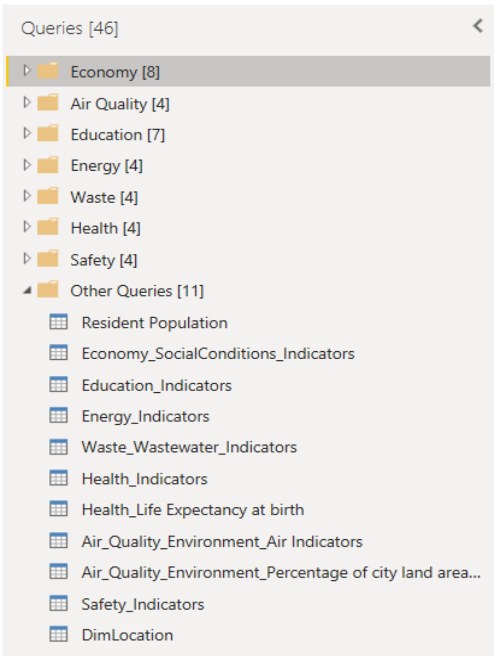


Figure 19 - Final Queries

Residing in topic named group folders, the unmerged queries were disabled to load to the Power BI data model.

The merged queries are loaded together with the *DimLocation* query, the *Resident Population* query which does not include itself in any indicator topic, being a supportive data for measure calculation, and the *Health_Life Expectancy at birth* query which could not be merged to it's respective topic since it has a divergent time period from the rest of the indicators.

The AQE indicators are also split between two queries, as a consequence of diverging time periods, one table aggregates all data for air quality and while another the data for the city's land usage.

4.4 Data Model

To complete the data model a few adjustments had to be made. With eleven tables loaded into Power BI's data model, a Date Dimension table, as previously stated in the conceptual model chapter, was created using Power BI's option to create tables based on a DAX language expression. The new table representing a Date Dimension is named *DimDate* (Figure 20).

```
DimDate =
ADDCOLUMNS (
CALENDAR ("1991-01-01", date(year(today())+1,month(today()),day(today()))),
"DateINT", FORMAT ( [Date], "YYYYMMDD" ), "Year", Year( [Date]))
```

Figure 20 - DimDate Dax Expression

The *Date* column specifies for each row a unique calendar date starting from the 1st of January 1991 to a year from the current date. The initial date was chosen considering the oldest indicator that was loaded into the model (Consumer Price Index).

The *Year* and *DateINT* columns, were calculated based on the *Date* column. Subsequent columns were added to table to provide more attributes (Table 12).

Table 12 - DimDate table columns

DimDate Created Columns	*DAX expression*	*Data Type*
Date	Calendar ("1991-01-01", date(year(today())+1,month(today()),day(today())))	Date
Year	Year([Date])	Whole Number
DateINT	Format ([Date],"YYYYMMDD")	Text
School Period	[Year]&"/"&[Year]+1	Text
Month Number	Month([Date])	Whole Number
Month	Format([Date],"MMM")	Text
Day	Day([Date])	Whole Number
Week	WEEKNUM([Date])	Whole Number

Following the new table addition, a *DateYearKey* column was added to most tables, formatting each respective *Year* column of each table to the format “YYYYMMDD”, defined as text data type.

For the table regarding Air Quality Indicators the *Data* column was used in creating a *DateYearKey* column and table *Education_Indicators* received it’s *DateYearKey* column by selecting the first year of the *School Period* column values.

The new columns *DateYearKey* and column *DateINT* of *DimDate* table will be the connecting related columns between each indicators table and the *DimDate* table.

The last column added in this development stage was indicator *Patents per 100.000 inhab.* of the table *Economy_SocialConditions_Indicators*. Initial data sourced for this indicator only stated the absolute value of patents registered per year and therefore the data for resident population was used to obtain the required indicator definition (Figure 21).

```
Patents per 100.000 inhab. =
                    divide(
                        Economy_SocialConditions_Indicators[No. Patents],
                        RELATED('Resident Population'[Residents])
                        )   *100000
```

Figure 21 - Indicator Patents per 100.000 inhab.

Lastly, all columns that did not represent a chosen indicator or provided insight or context to an indicator, as well as the *Resident Population* table, were hidden from report view as to not create clutter in Power BI's Fields pane.

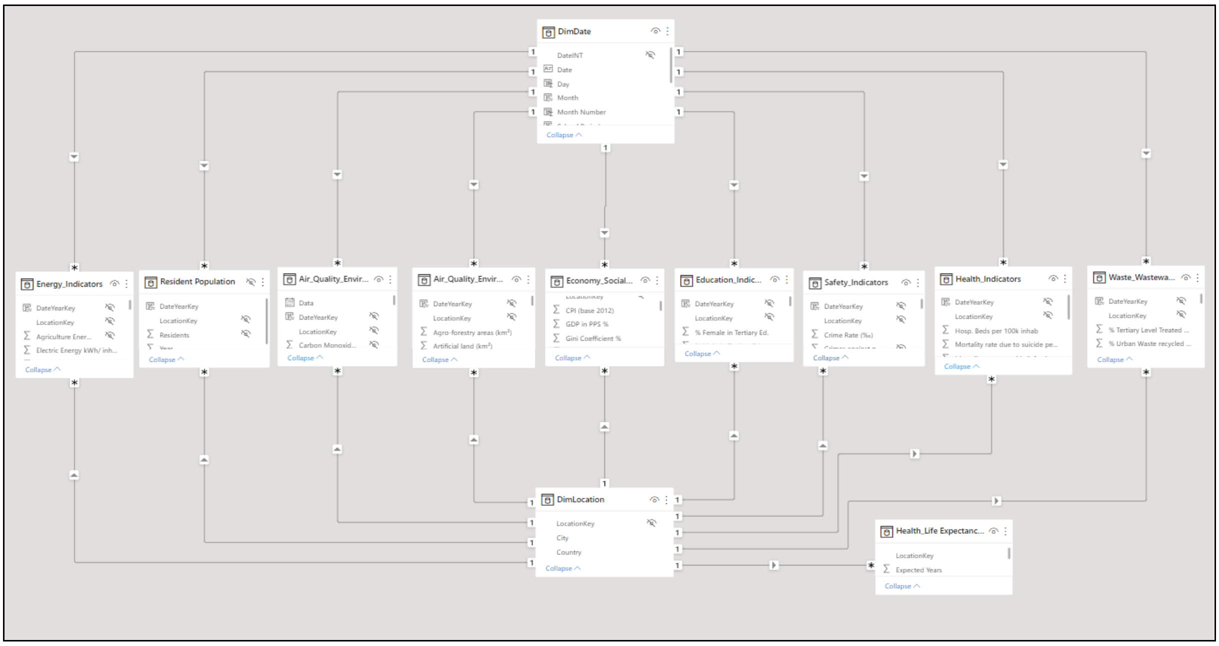


Figure 22 - Final Model view

4.5 Measures

As described in the conceptual model chapter, to analyse indicator performance over time, evolution measures needed to be calculated, additionally, some indicators needed to be created through measures because the sourced data did not meet the required indicator definition.

Created measures are calculated using DAX expressions which can be consulted in the Appendix, the following Table 13 specifies for each table, the created measures and format.

Table 13 – Created Measures

Table	*Measure*	*Format*
Air_Quality_Environment_Air Indicators	Avg. Nitrogen Dioxide (µg/m³) Avg. Ozone (µg/m³) Avg. Particulate Matter 10 (µg/m³) Avg. Particulate Matter 2.5 (µg/m³) Avg. Sulfur Dioxide (µg/m³)	Decimal Number
	% Variation Carbon Monoxide Avg. % Variation Nitrogen Dioxide Avg. % Variation Ozone Avg. % Variation Particulate Matter 10 Avg. % Variation Particulate Matter 2.5 Avg. % Variation Sulfur Dioxide Avg.	“+0.0%;-0.0%”
Air_Quality_Environment_Percentage of city land area by land use and cover	% Agro-forestry Area % Artificial Land Area % Cropland Area % Forest Area % Grassland Area % Open Spaces or Sparce Vegetated Area % Shrubland Area; % Surface Water Bodies Area % Wetlands Area	Percentage
	% Agro-forestry area vs last registry % Artificial Land area vs last registry % Cropland area vs last registry % Forest area vs last registry % Grassland area vs last registry % Open spaces or sparce vegetated area vs last registry % Shrubland area vs last registry % Surface water bodies area vs last registry % Wetlands area vs last registry	“+0.00 pp;-0.00 pp”
Economy_SocialConditions_Indicators	Gini Coefficient vs N-1 Resident Population at risk of poverty vs N-1 Survival Rate of Enterprises vs N-1 Unemployment Rate vs N-1 Youth Unemployment Rate vs N-1	“+0.00 pp;-0.00 pp”
	Patents per 100k Residents vs N-1	“+0.0%;-0.0%”
Education_Indicators	% Female in Tertiary Ed. vs N-1 % Male in Tertiary Ed. vs N-1 Completion Rate Primary Ed. vs N-1 Completion Rate Secondary Ed. vs N-1	“+0.00 pp;-0.00 pp”
	Females Enrolled Tertiary Ed. vs N-1 Males Enrolled Tertiary Ed. vs N-1	“+0.00%;-0.00%”

	var Avg. Students non-tertiary per computer N-1 var Graduates Tertiary Ed. per 1000 hab. vs N-1 var Primary Ed. Student/Teacher Ratio vs N-1	Decimal Number
Energy_Indicators	% Agriculture Energy cons. % Industry Energy cons. % Non-Residential Energy cons. % Other Energy cons. % Residential Energy cons. % Lighting of public buildings Energy cons. % Other Energy Consumptions % Public Road Lighting Energy cons.	Percentage
	% Lighting of public buildings cons. vs N-1 % Public Road Lighting vs N-1	“+0.00 pp;-0.00 pp”
	Electric Energy kWh/inhab. vs N-1 Household electric Energy kWh/cons. vs N-1 Natural Gas per 1k inhab. vs N-1	“+0.00%;-0.00%”
Health_Indicators	Var. Hosp. Beds per 100k inhab vs N-1 Var. Mortality rate due to suicide per 100k inhab (No.) vs N-1 Var. Mortality rate parasitic/infectious dis. per 100k inhab vs N-1 Var. Under-Five Mortality per 1000 live births (No.) vs N-1	“+0.00;-0.00”
Health_Life Expectancy at Birth	Variation Expected Years	“+0.00;-0.00”
Safety_Indicators	Fire Brigades per 100k Inhab. Firemen per 100k Inhab. Homicides per 100k Inhab.	Decimal Number
	Var. Crime Rate vs N-1 Var. Fire Brigades vs N-1 Var. Fire Brigades vs N-1 Var. Homicides vs N-1	“+0.00;-0.00”
Waste_Wastewater_Indicators	% Solid waste for energy recovery % Solid waste for landfill % Solid waste for multimaterial recovery % Solid waste for organic recycling	Percentage
	Total Collected Solid Waste per capita (ton)	Decimal Number
	% Solid waste for energy recovery vs N-1 % Solid waste for landfill vs N-1 % Solid waste for multimaterial recovery vs N-1% Solid waste for organic recycling vs N-1 % Tertiary Level Treated Wastewater vs N-1 % Urban Waste recycled and reused vs N-1 Index wastewater sanitation services % vs N-1	“+0.00 pp;-0.00 pp”

	Total Collected Solid Waste per capita (ton) vs N-1	“+0.00%;-0.00%”
	var Total Collected Solid Waste per capita (ton) vs N-1	“+0.000;-0.000”

4.6 Dashboard

Using Microsoft’s PowerPoint, a background image was designed for each dashboard page in efforts of making the Power BI dashboard as responsive as possible refraining from including individual visual design artifacts.

The Overview page (Figure 23) presents only core indicators and economy profile indicators, it is designed to give the user an overall view of all areas of sustainability considered for the report. With the use of the filter provided in the top right corner of the page, users can identify what values were observed in each selected year and analyse how indicators compare over the previous year’s reported value. For all pages of the Power BI report a location dimension filter was applied to consider indicators for “Lisbon”.

Each area of sustainability is figuratively represented by a figure for a clearer design uncluttered by too much text. Indicators directly under each figure are related to the represented area of sustainability. To the left of the page, the navigation menu gives more context to each figure.

The core indicators are grouped over two sections sharing the same colour background indicating connection and highlighting both sections.

Values for ESC, Education, Health, Safety, WWM and Energy are all displayed over the top half of the page, each indicator value is highlighted and labelled below, performance indicators are displayed under each label where a colour code has been attributed, red (#CD4C46) represents a negative performance while green (#73B761) represents a positive performance. This upper section of core indicators will be present in every subsequent dashboard page, only not highlighted.

The bottom left corner, also colour highlighted, displays two core indicators for AQE in a column chart display for comparative purposes between both indicators. Performance indicators for each measure can be consulted when hovering over the display, a tooltip box presents the observed value, the observed year, and each indicators performance over last year’s value (Figure 24).

Economy Profile Indicators are displayed over the bottom left corner in a line and column chart, for cleared comparison between each indicators evolution over time all indicators are displayed over X axis for Years. The background differs in colour from the core indicators so the user can easily distinguish information.

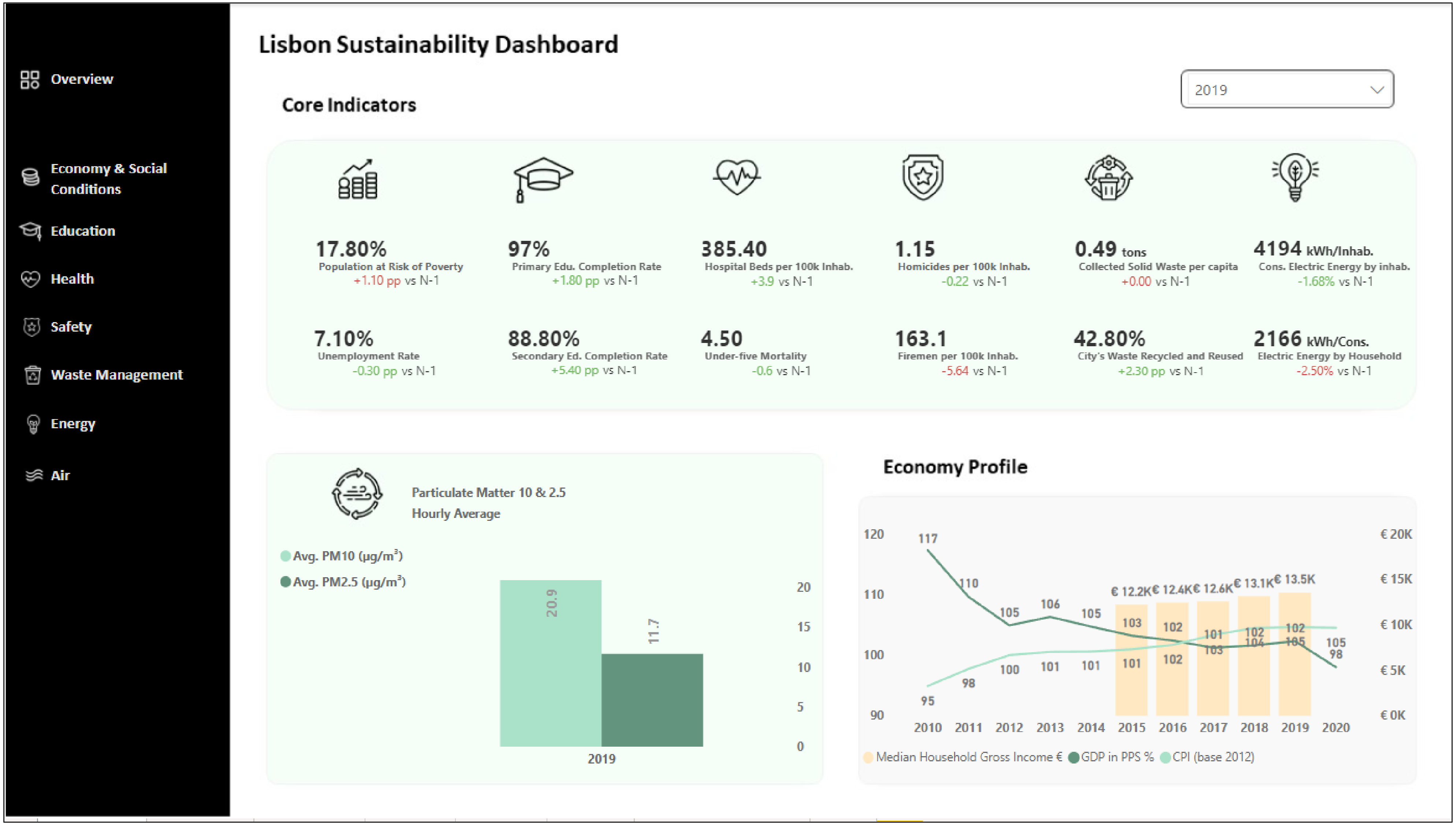


Figure 23 - Overview Dashboard Page

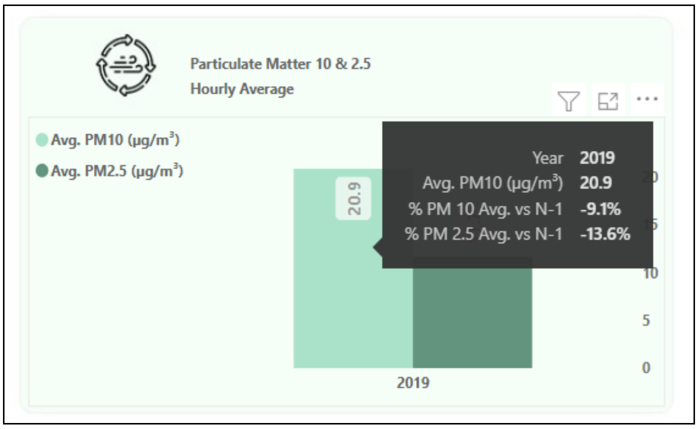


Figure 24 - Tooltip function

When selecting any of the options on the navigation menu to the left, the page changes accordingly.

For the ESC dashboard page (Figure 25) the core indicators displayed above maintain their display, while the lower half section of the dashboard changes to now display all indicators regarding ESC. This section is titled according to what area of sustainability is being addressed.

The filter on the top right corner of the page continues to only influence the core indicators pane and the page navigation menu is now collapsed as to not take too much space. It can still be accessed when selecting the menu icon at the top left corner.

The colour scheme changes from the core indicators pane being highlighted with colour to now the graphs that present the ESC indicators being highlighted.

The lower half section of the dashboard starts to the left by displaying the *Total Unemployment Rate* and *Youth Unemployment Rate* in percentages over years. Both indicators are displayed in the same line chart so the user can analyse both indicators in comparison more easily. To the right of this chart are four chart equally distributed and labelled for indicators *Resident Population at Risk*, *Gini coefficient*, *Survival Rate of Enterprises born two years before* and *Patents per 100.000 inhab.*, all charts are over a Years X axis to show evolution over time while the tooltip function always shows performance over previous year's value.

Observing the line chart to the left, *Youth Unemployment Rate* clearly displays values above Total Unemployment while both had diminishing values from year 2013 until 2018 and 2019, where both indicators reached their lowest observed values. Both indicators are increasing over the previous year in the last observation available.

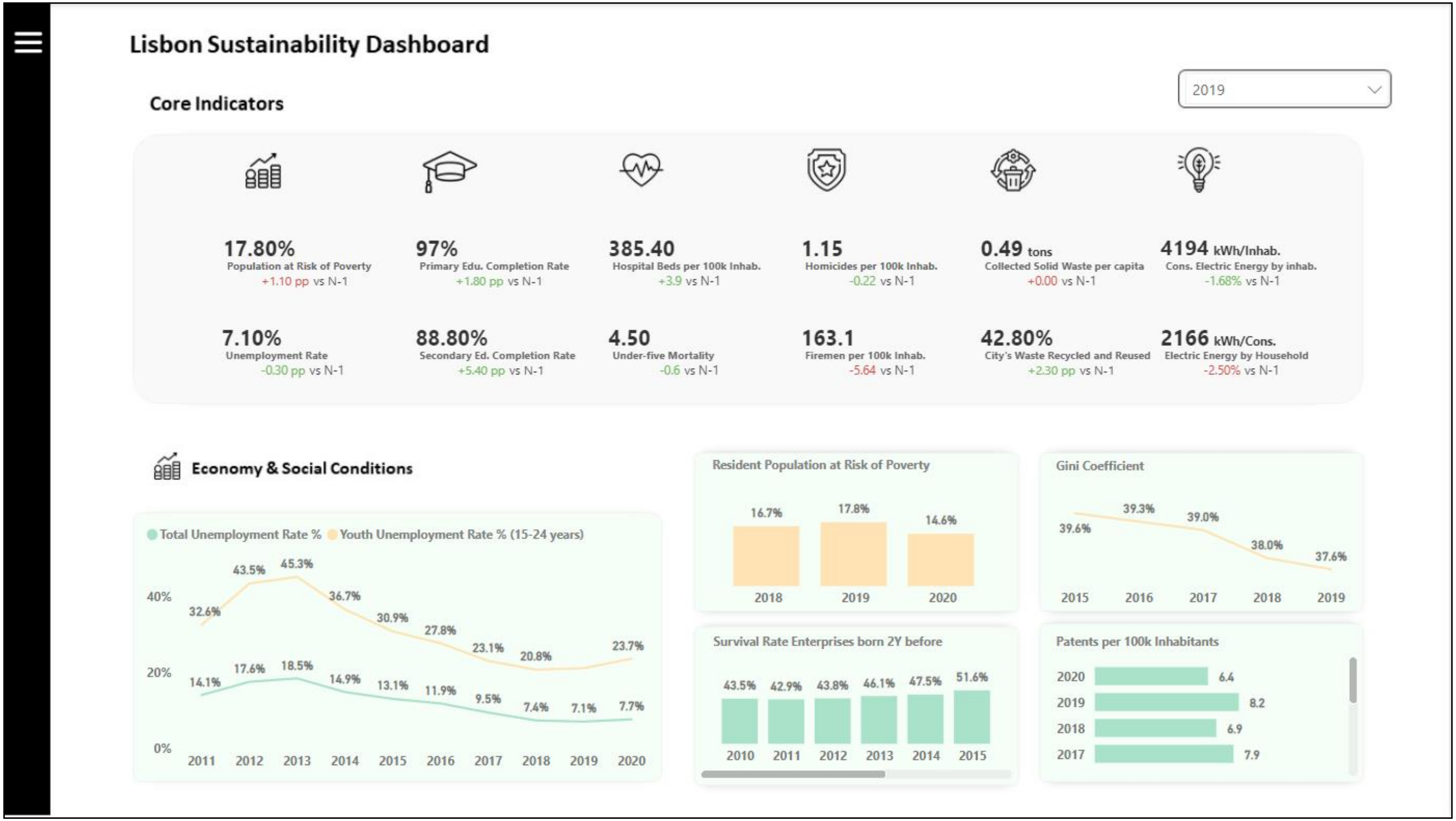


Figure 25 - Economy and Social Conditions Dashboard Page

Over to the right side of the page, it is evident the decrease in the *Gini Coefficient* indicator and *Resident Population at Rick of Poverty* showing a decrease over the last observed value which would indicate improvement in social economic standards for Lisbon. *Patents per 100k Inhabitants* displays a decreasing tendency which would indicate a tendency for less innovation and *Survival Rate Enterprises born 2Y before* shows a steady increase since 2011 while it has decreased -0.50 pp on the last observed year as indicated on the tooltip.

The Education Dashboard Page (Figure 26) has five charts over the lower half of the page, having two line charts at the centre, to the right, two smaller column charts and to the left a vertically oriented stacked bar chart.

The top line chart compares *Completion Rate of Primary Education* and *Completion Rate of Secondary Education* where it is clear the improvement for both indicators over the last decade. The line chart at the bottom indicates the evolution of the *Primary Education Student/Teacher Ratio* over time, having reached a peak in number of students for one teacher in years 2013 and 2014 but showing a descendent tendency from 2014 onward.

Graduates of tertiary education per 1000 inhabitants and *Average number of students enrolled in non-tertiary education by computer connected to the internet* are displayed to the right in column charts. Graduates have increased significantly from the first observable value of 63.8 graduates in 2005 to the last observable value in 2019 of 108.9 graduates and maintaining a steady increase over the last five recorded years. For the number of students in non-tertiary education by computer it is of significance the -6.9 student to computer variance from 2007 to 2008 which suggest an investment in available computer for students.

Lastly, to the right side of the page a stacked bar chart compares the percentages of *Students enrolled in tertiary education by sex*. While slight variations are seen over the years the main observation from this indicator is that females represent consistently over 50% of the observed population being the highest observed value of 53.4% in 2018.

The Health Dashboard Page (Figure 27) consists of four charts beyond the core indicators display at the top. Of the four charts three are column chart.

To the left a stacked column chart displays values for Life Expectancy at birth in years over each period of time, every column consists of the value for expected life years followed above by the variation in years to the previous period's value. To provide the user with better readability over each measure, the chart has to it's left a zoom slicer on the Y axis that the user can adjust to zoom in on any smaller values that are not displayed in the charts original form. The latest value of life expectancy indicates 81.14 years with a +0.13 year variation to the previous period. Over time the indicator has increased indicating an improvement in health standards for Lisbon.

To the right a line chart shows *Under-five Mortality per 1000 live births*, the latest value for year 2020 is also the lowest value observed at 2.9 deaths with a variation of -1.6 deaths per 1000 live births from previous year.

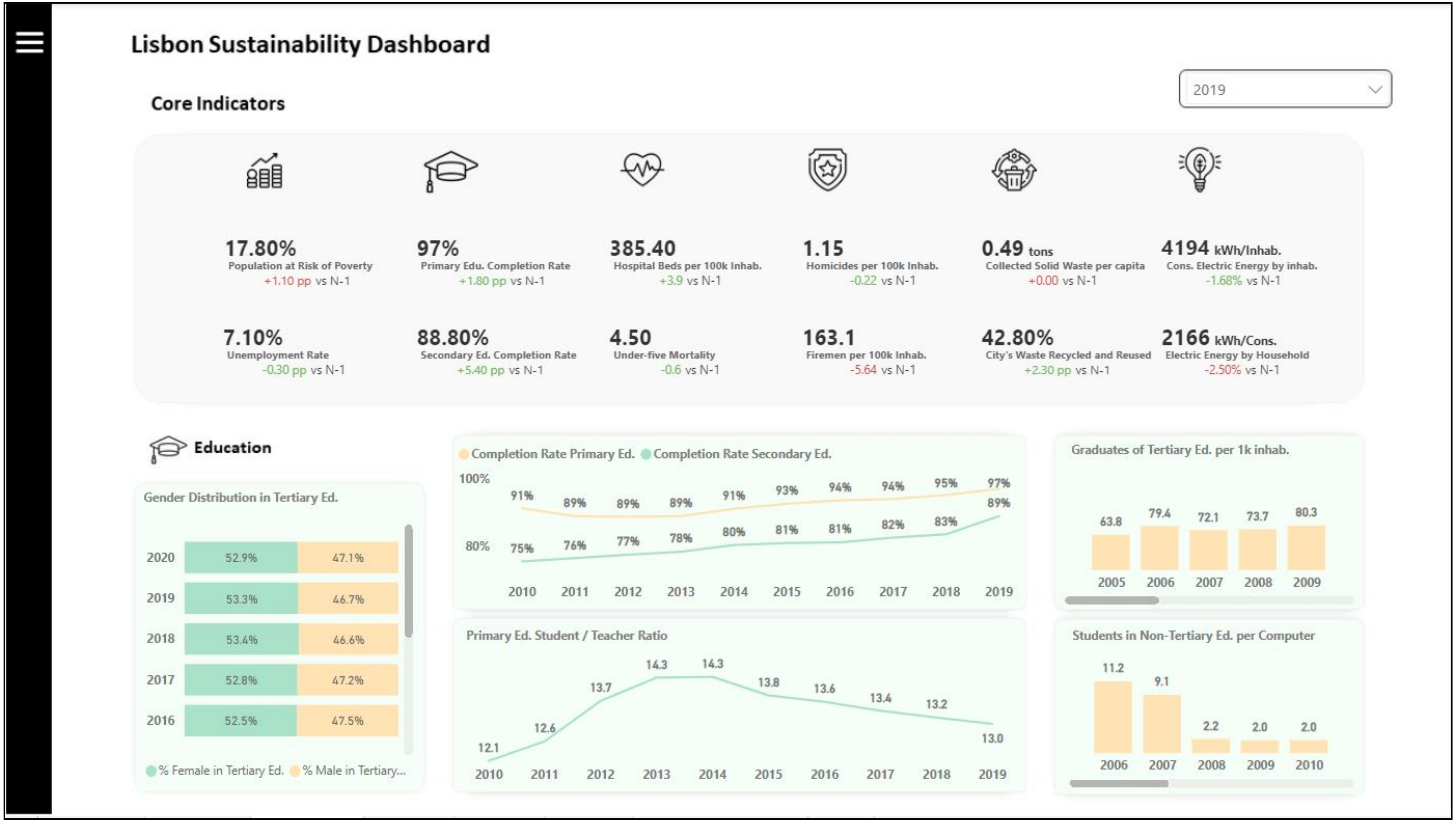


Figure 26 - Education Dashboard Page

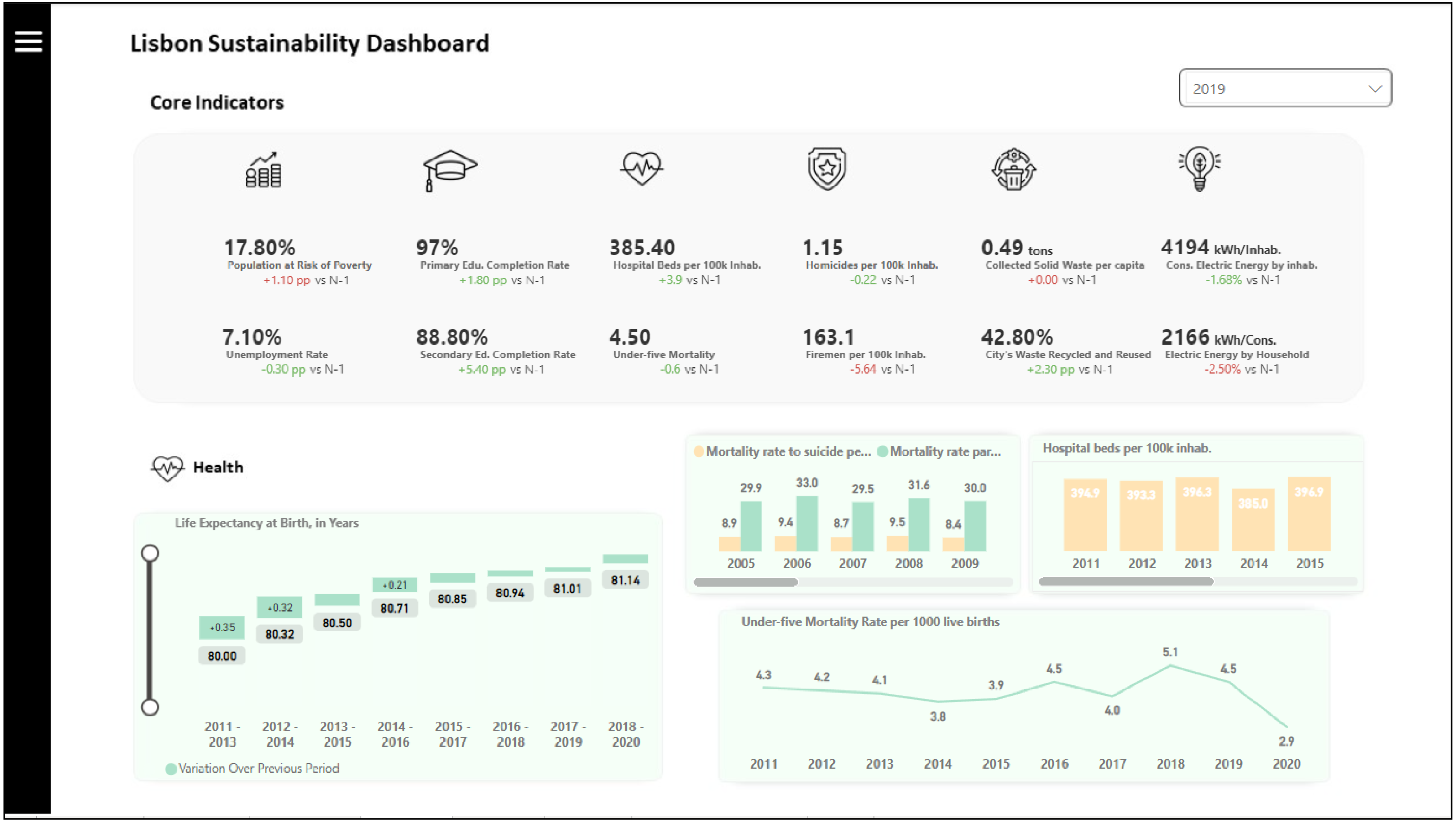


Figure 27 - Health Dashboard Page

Above the line chart, two column charts are displayed, one of which compares the *Mortality rate due to intentional self-harm (suicide) per 100.000 inhabitants* and the *Mortality rate due to some infectious and parasitic diseases per 100.000 inhabitants.*

This chart shows that the mortality rate due to parasitic and infectious disease is consistently above the mortality rate due to self-harm, and that both indicators show positive and negative variations over the years. While the mortality rate for parasitic or infectious diseases has shown its lowest values from 2014 onward the mortality rate due to self-harm has only achieved its lowest value in the latest recorded year of 2019.

To the right of the previous mentioned chart a column chart indicates the number *of Beds of hospitals per 100.000 inhabitants.* This indicator also displays positive and negative variations over the years being the latest value of 385.4 beds per 100.000 inhabitants representing an increase of 3.9 beds from the previous year.

For the Safety Dashboard Page (Figure 28) the four indicators of the respective area are displayed over two line charts and two column charts.

Crime rate (‰) per 1000 inhab. is displayed to the left, the user can clearly see a declined in crime rate over time with slight positive variations in year 2015 and 2017 but continuing its downward trend and achieving the lowest and most recent value of 31 crimes per 1000 inhabitants in 2020.

Firemen per 100.000 population and *Fire brigades (No.) per 100.000 population* are shown in side-by-side column chart since they are non-comparable indicators but both measure Lisbon's Fire Department's resources. Fire brigades by population doesn't show significant changes, only a slight decrease in latest year suggesting an increase in population while Lisbon's number of fire brigades remains the same throughout the years. The number of firemen per population however has been diminishing reaching it's lowest value on the latest recorded year of 2020 of 158.6 firemen per 100.000 inhabitants.

Values for *Number of homicide per 100.000 population* indicator are displayed over a line chart below the preciously described charts. By observing the chart, the user can visualise the indicator over all reported years. The latest value indicates 1.2 homicides and when analysing the chart, the indicator varies from 0.6 to 1.5 and out of the ten year observations the indicator maintains a consistent range from 1.2 to 1.5 in eight years.

Figure 29 shows the Waste and Wastewater Dashboard Page where five charts are displayed. The layout of these charts is similar as that of the ESC Dashboard with a larger chart to the left and to the right four smaller charts divide the space equally.

The larger chart to the left indicates the destination of the city's solid waste in percentage. The indicators *Percentage of city's solid waste that is disposed of in sanitary landfill* and *Percentage of city's solid waste that is used for energy recovery* are represented here alongside the remaining destinations that were sourced simultaneously. Including the remaining destinations of solid waste gives the user a complete understanding of the information.

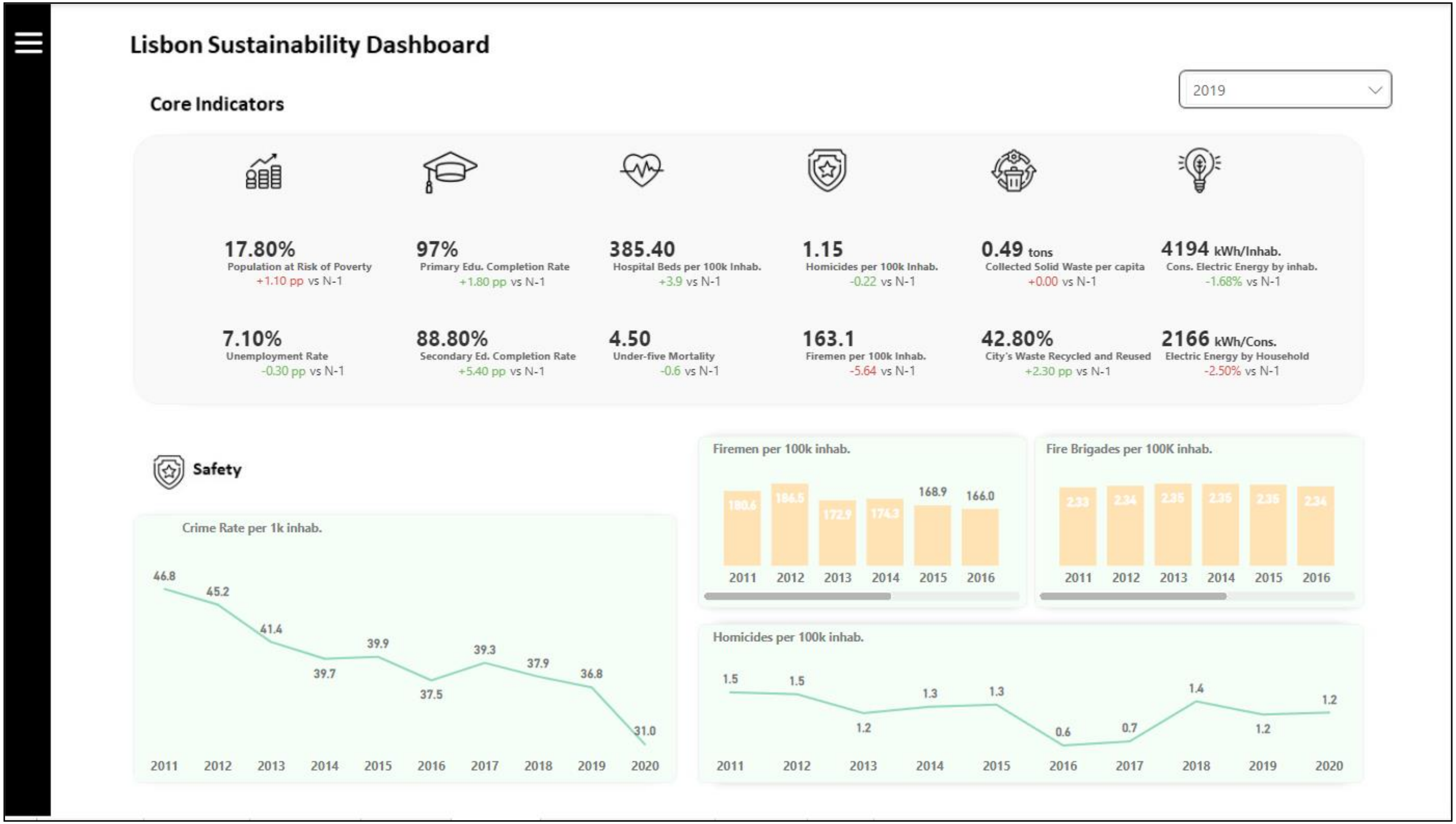


Figure 28 - Safety Dashboard Page

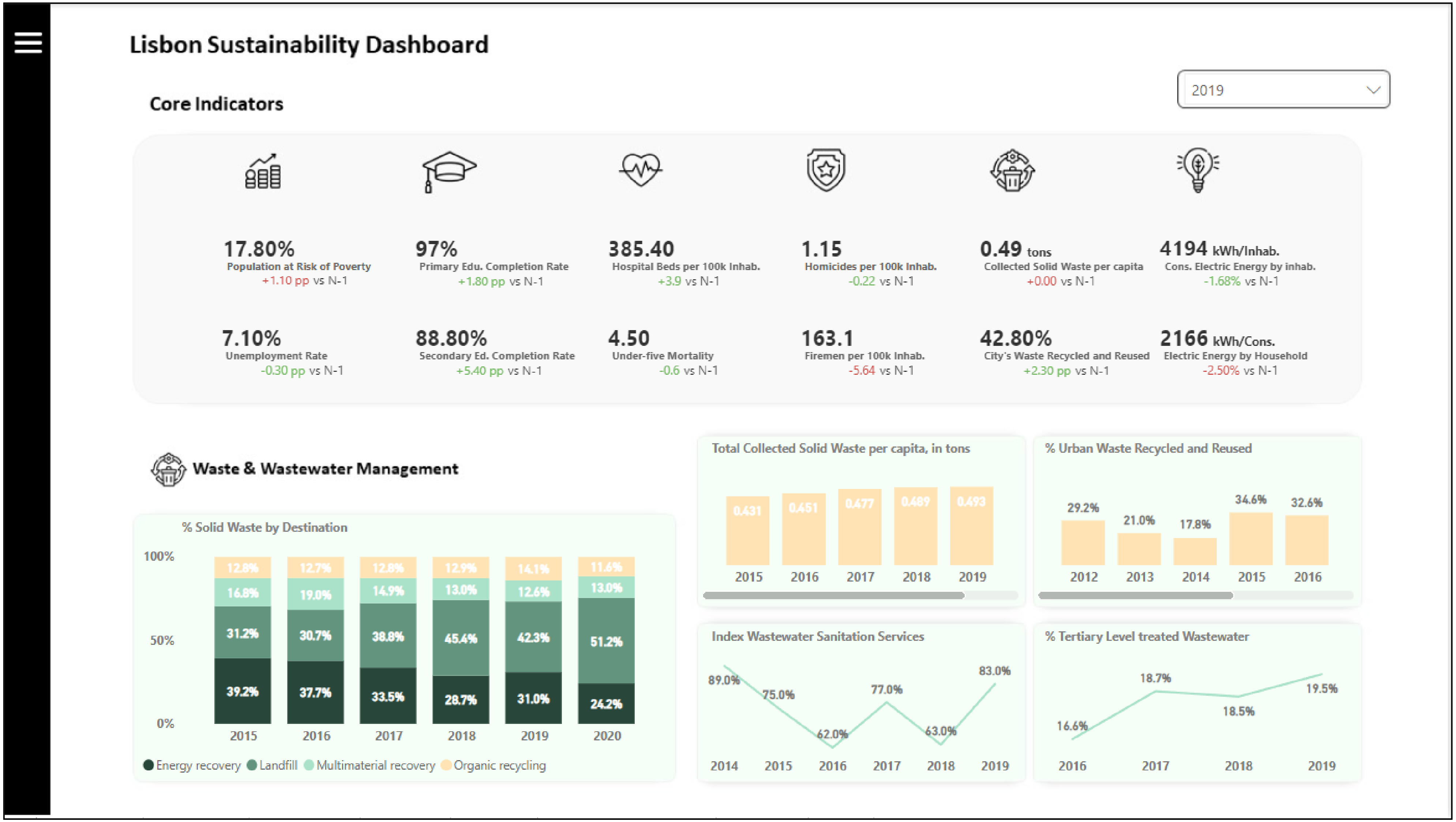


Figure 29 - Waste and Wastewater Management Dashboard Page

Analysing the chart, most of the solid waste is destined for energy recovery and for landfills, while only a smaller percentage is used for multimaterial recovery and organic recycling. Of both indicators the core indicator regarding the landfill destination has evolved over time to represent a larger percentage of the destinations, reaching 51.2% in 2020, while energy recovery substitute indicator shows significant diminishing percentages.

The charts to the right are organized by subject to better situate the user, the two top charts represent *Total collected solid waste per capita* and *Percentage of city's urban waste that is recycled and reused,* both indicators regarding waste management and both bottom charts represent wastewater management related indicators by showing *Quality index of bulky wastewater sanitation services (%)* and *Percentage of tertiary level treated wastewater*.

Total collected solid waste per capita shows little variation over time, being the latest value of 0.479 tons of solid waste collected per capita while *Percentage of city's urban waste that is recycled and reused* shows greater performance over time being the last two recorded years the highest observable values with 40,5% for 2018 and 42.8% for 2019.

Over the bottom two charts the wastewater indicators suggest an improvement in the percentage of water receiving tertiary level treatment almost reaching the 20% mark and 83% sanitation service in 2019, with an improvement of +20 pp over 2018.

The Energy Dashboard Page (Figure 30) has only three charts regarding a total of five indicators. Both *Percentage Electric consumption of public buildings (kwH)* and *Percentage Electric consumption of public street lighting (kwH)* are displayed over the leftmost chart in a stacked column chart.

Both indicators share a 100% bar with the calculated measure *% Other Energy Consumptions* which sums the remaining consumptions for electric energy and represents values consistently above 90%, due to this the Y axis on the chart is limited to start at value 0.8 so the indicator's values are clearly visible to the user as they represent a significantly smaller fraction of the whole energy consumption.

In this chart the option to use the sum of all other energy consumptions in detriment to using the distinct values for each consumption was based on primarily highlighting the chosen indicators for this display. Using each distinct classification of consumption would clutter the display and the user would lose sight of the indicators the dashboard is emphasising.

To the right of the page and above, a column chart represents *Consumption of natural gas per 1000 inhabitants (Nm^3)* where a decrease in consumption is noticeable from 2012 to 2016 and again from 2018 to 2019, being 2019 the latest value available.

Observing the final chart in the page it is noticeable the higher values for *Consumption of electric energy by inhabitant (kWh/ inhab.)* over the values for *Household consumption of electric energy by consumer (kWh/ cons.).*

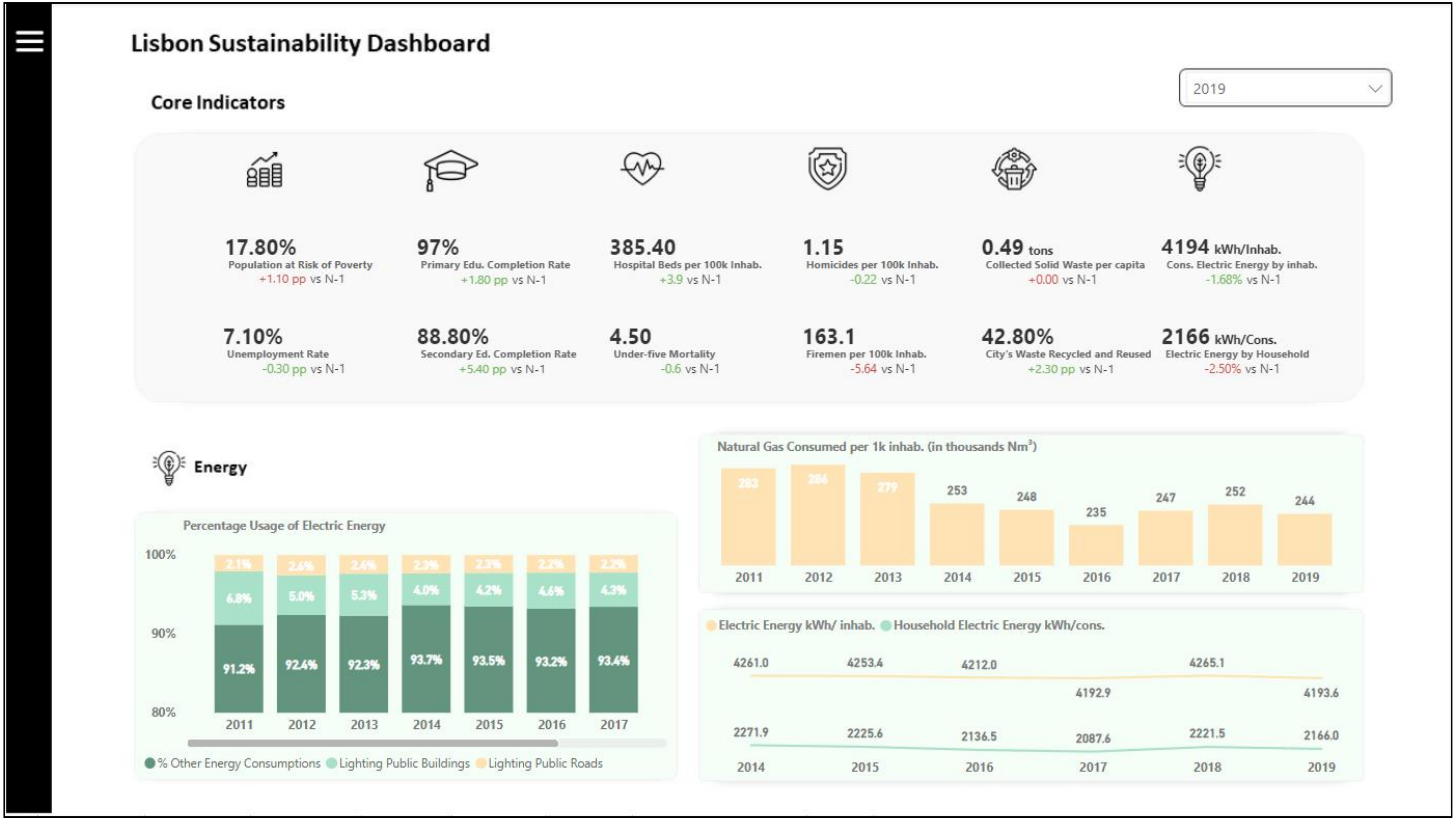


Figure 30 - Energy Dashboard Page

The Air Quality and Environment Dashboard Page (Figure 32) is conceptually designed similarly to previous dashboard pages but it's displays are adjusted to the larger amount of data sourced for this area of sustainability.

To the left a pie chart details the indicator *Percentage of city land area by land use and cover,* this indicator only has observable data points for three years and to provide the user the option to navigate and consult each year's values a discrete slicer by year is provided to the left of the chart. To this slicer a visual filter was applied were the field *Year* of table *Air_Quality_Environment_Percentage of city land area by land use and cover* is not blank. This filter implies that the year values available on the slicer are only those that are available as data points on the indicators table.

All areas of land are shown on the chart and the data labels read the name and percentage value. Different colours were chosen for each land classification. On the tooltip all variations are calculated in comparison to the previous recorded year.

Observing the chart most of Lisbon's area is defined as Cropland with a percentage of 27.37%, followed by Forest area with a value of 24.62% and Artificial land with 21.68%. From year 2015 to year 2018 the biggest absolute change happened in Cropland area increasing its percentage by +0.23 pp.

The right area of the page displays the air quality indicators. A vertically oriented column chart compares average hourly values for each indicator in micrograms per cubic meter (µg/m³). Above this chart seven selection buttons are visible, being the default selected button "Year Avg.". The user can select each button to change the chart display below accordingly.

The area changes to only displaying a horizontally oriented line and column chart (Figure 31) that indicates the average values for *Level of Particulate Matter 10 (µg/m3)* indicator and the percentage evolution over the previous year as a line. These single indicator charts have a drill-down option over the X axis, detailing years into months with the usage of Power BI's chart drill-through options.

When observing the "Year Avg." default chart for PM10, PM2.5, Nitrogen Dioxide and Sulfur Dioxide all show diminishing values over the last three reported years while Ozone values reach a peak high in 2020 and Carbon Monoxide registers a -3.4% variance in 2020.

Figure 31 - Level of Particulate Matter 10 (µg/m3) chart

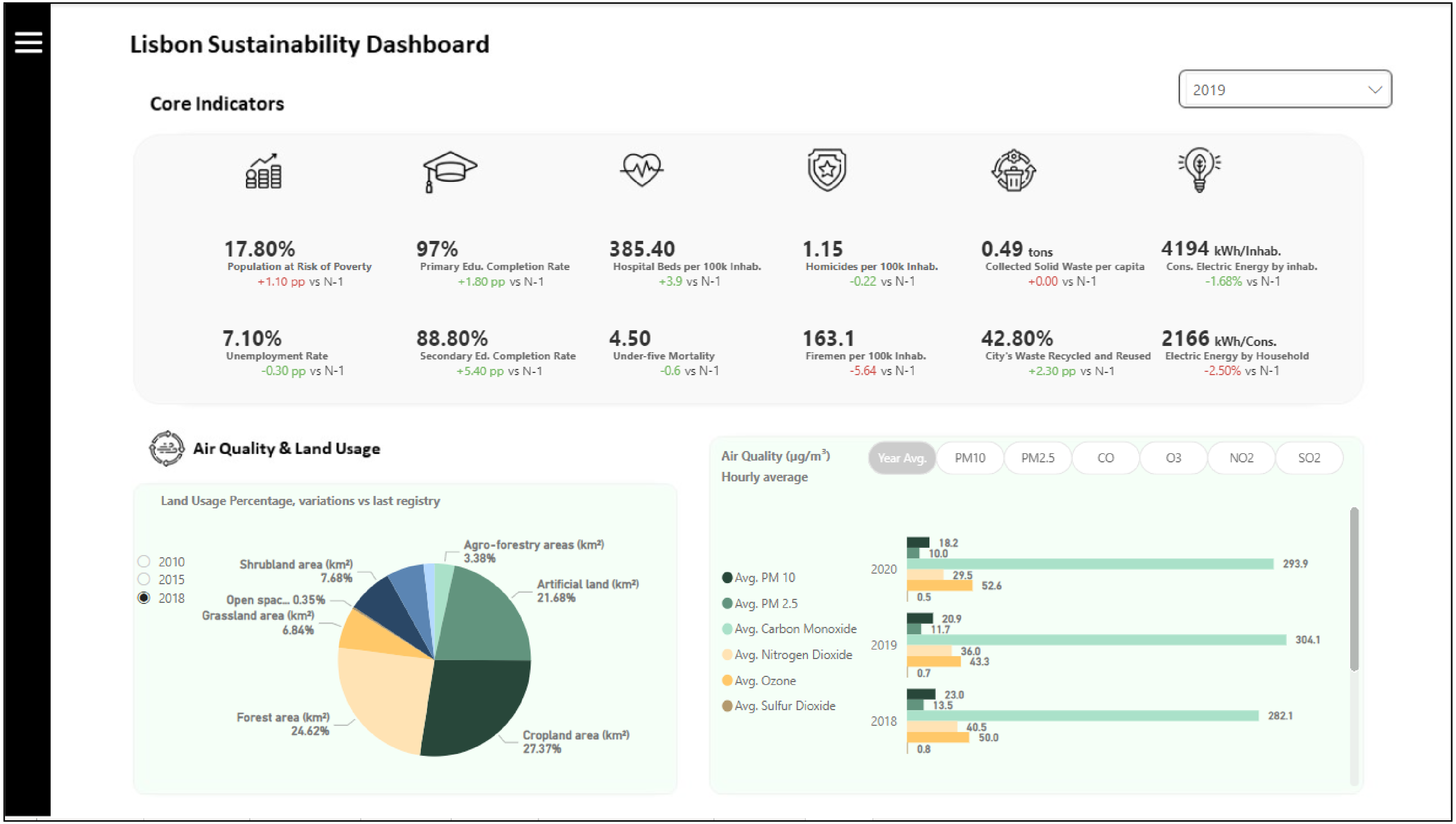


Figure 32 - Air Quality and Environment Dashboard Page

5 RESULTS AND DISCUSSION

This chapter aims at evaluating the result of the project's final artifacts, the dashboard developed, in meeting expectations based on the literature review and the proposed conceptual model.

The project collects data about Lisbon's sustainability through varied indicators that are established as standardized indicators for sustainable development in communities and cities through the UN and ISO organizations.

The collected data is transformed into useful information by extracting, transforming, and loading the data through a process applied with on demand tools provided by the project's development tool, Power BI. The process to which the data goes through is automated, being solely dependent on the sources maintaining the same standards over each data update that occurs, to minimize any adjustments that could be needed in future updates of the projects data.

A structured model of data is implemented with dimensions that facilitates the analysis of indicator performance over time and location.

This analysis is possible through several clear, organized dashboards that provide the user with any necessary information about the regarded indicators.

The dashboard provides different levels of detail and information, starting from an initial page that gives an overview of a collection of categorized indicators, identified as core indicators for each respective area of sustainability. From here a user can quickly view sustainability performance over core indicators for the city with the help of the created measures that indicate evolution over previous years. It is also possible to navigate through different year´s data using the provided filter.

A deeper and more detailed understanding of each area of sustainability is possible, through a simple navigation menu that takes the user to the desired area´s dashboard page, where indicators are displayed in a more graphical design and over time analysis is visually possible by analyzing each chart.

The dashboard's content aims at being as simple and comprehensible for the user as possible, not including unnecessary information. Visually displaying the indicators values and delivering more insight with the aid of chart´s tooltips.

The dashboard´s content layout always seeks to be arranged in a meaningful way, by giving the necessary space to each indicator and positioning kindred contents in spaces close together, so the user can quickly shift their attention and still gather insightful information.

6 CONCLUSIONS

As defined in the introduction, the aim of the project was to produce an informative dashboard, using BI tools that allow for easy gathering and reading of information about the sustainability of the city of Lisbon.

The dashboard should be based on data available to the public through public organizations and it should make monitorization of the city's evolution towards sustainability a simple task, by allowing the observation of evolution over time and performance of important indicators of sustainability.

By gathering data from INE and Agência Portuguesa do Ambiente, the dashboard's data regarding sustainability is displayed over eight different dashboard pages created through Microsoft's Power BI.

Over every page performance over time is displayed, the development stage of the project revealed that information is simple and easy to read.

The analysis of the present indicators suggests that, overall progress towards sustainability and better conditions are taking place in Lisbon over the recent decade in some areas, while others lack developments.

We can analyze Economy Profile indicators in the Overview Page and identify a slight, yet steady, increase in the Median Household Gross Income for the city of Lisbon over the recorded years, however the decrease in GPD in PPS indicates a loss of purchasing power compared to the European standard while CPI displays a steady increase.

While some areas of sustainability might exhibit better performance throughout each indicator, such is the case of indicators concerning Education, where it is clear a positive performance over all indicators in recent years, other areas show good performance evolution for some indicators while others might fall behind.

In Education all indicators provide a positive view of development, completion of primary and secondary education both reached an all-time high percentage in the latest record, which corresponds with the education system having more teachers available per student over recent years. We can also see a positive transition in the increase of percentage of the population that graduates tertiary education.

The case for Economy indicators is that of improvement in some indicators but lacking others development. Better social conditions and more even distribution of wealth are observed in the Population at Risk of Poverty and the Gini Coefficient charts respectively, while the remaining indicators contradict a consistent positive evolution over the 2010 decade, both displayed unemployment rates show an increase in the most recent recorded year, patents per inhabitants are diminishing consistently and survival rate of enterprises has come to a halt in improvement and shows a slight decrease in recent years.

For Health indicators, Lisbon shows an improvement in Life expectancy over the years, but other indicators show some additional action should take place since the mortality rates analyzed and the availability of hospital beds per inhabitant show inconstant improvement over time.

Safety indicators show that improvements are mostly present in crime rate, having decreased in recent years, while Lisbon's Fire Department has maintained steady resources with slight decrease in the number of firemen per population numbers.

For Waste and Wastewater Management the analysis conclusion seems to indicate that landfills have been used to a higher demand in recent years in solid waste destinations but the percentage of urban waste that is recycled and reused has also increased over the years, forming another example of improvements in some indicators while others lack positive development.

The Energy indicators provide an overview of energy consumption, where the Natural Gas Consumption has shown decreasing values over the years but other indicators don't display significant variations, leading to the conclusion that not many changes have taken place over the years.

Lastly the Air Quality and Environment page provides a more dynamic analysis of the several indicators of air quality. The overall analysis is that improvements in the levels of some air components have been noticed over recent years, such as in PM10, PM2.5, Nitrogen Dioxide and Sulfur Dioxide. While Ozone and Carbon Monoxide levels show little to no improvement.

The dashboard provides the means for a clear analysis over time and, evidently, room for improvements in some of the regarded indicators are apparent, while others already show a positive development.

The project is prepared for updating any data for future analyses with the most recent data as it is made available by the source public organizations.

However, it should be noted that, when confronting the obtained data with the conceptualized data necessary, only 33% of indicators were obtained and substitute indicators had to be added to provide more information to the considered topics of sustainability.

The open-source data considered does not provide most of the indicators that were conceptualized and described in the literature review and subsequently the dashboard fails to provide all the necessary data to form a complete analysis of sustainability for Lisbon in these topics of sustainability.

7 LIMITATIONS AND RECOMMENDATIONS FOR FUTURE WORKS

Limitations of the project were manifested primarily in the gathering of the desired data for the development of the project.

The literature review resulted in the identification of several indicators that are appropriate for sustainability measurement. Categories for each indicator are defined, while some are considered core indicators others are considered supporting indicators.

While there are numerous indicators defined, the actual recording of said indicators may not be available. The organizations that gather the data for each indicator are frequently independent from the organizations that define viable indicators to follow and as such the availability of said indicators cannot be guaranteed.

Being dependent on the available open-source data, brought necessary adjustments to the project´s considered indicators, and substitute indicators had to be considered to provide additional data to aim towards the projects objectives and provide information about sustainability for the city of Lisbon.

Making use of the national statistics institute (INE) that aggregates, records and provides data from multiples sources and areas of Portugal's activities, it was evident that, some topics had significantly lower percentages of matching the indicators considered for this project, from ISO organization, and indicators available.

For Energy topic, none of the wanted indicators were available, which might have impacted the results and conclusions attained from this area. Other significantly lower percentages of indicators available were Economy and Social Conditions with only 36% of indicators available, Waste and Wastewater Management with 21% and Safety with 20%.

None of the areas of sustainability had full availability for all indicators, which might also be influenced given the specificity that only indicators regarding Lisbon were considered.

Future related projects should be aware of the scarcity of some desired data when the attaining of this data is dependent on statistical public institutions. At the time it is apparent that further efforts to provide data to the public that satisfies the international standards in this topic of sustainability is needed.

Limitations were also encountered while defining the best possible manner to gather data from each source. While bets possible solution to extracting data from the data portals was an API connection to the data source, the required API connection settings for the desired data structure could not be found by the author. In future projects this might a point of improvement over the chosen solution o data extraction.

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9 APPENDIX

Table 14 - Model Created Measures and DAX Expressions

Measure	*DAX Expression*
Avg. Carbon Monoxide (µg/m^3)	AVERAGE([Carbon Monoxide (µg/m3)])
Avg. Nitrogen Dioxide (µg/m^3)	AVERAGE([Nitrogen Dioxide (µg/m3)])
Avg. Ozone (µg/m^3)	AVERAGE([Ozone (µg/m3)])
Avg. Particulate Matter 10 (µg/m^3)	AVERAGE([Particulate Matter 10 µm (µg/m3)])
Avg. Particulate Matter 2.5 (µg/m^3)	AVERAGE([Particulate Matter 2.5 µm (µg/m3)])
Avg. Sulfur Dioxide (µg/m^3)	AVERAGE([Sulfur Dioxide (µg/m3)])
% Variation Carbon Monoxide Avg.	Switch(True(), isinscope(DimDate[Month]), if(AND([Avg. Carbon Monoxide (µg/m^3)] <> blank(), calculate([Avg. Carbon Monoxide (µg/m^3)],PREVIOUSMONTH(DimDate[Date]))<>blank()) ,divide([Avg. Carbon Monoxide (µg/m^3)], calculate([Avg. Carbon Monoxide (µg/m^3)], PREVIOUSMONTH(DimDate[Date])))-1 ,blank()), isinscope(DimDate[Year]), if(AND([Avg. Carbon Monoxide (µg/m^3)] <> blank(), calculate([Avg. Carbon Monoxide (µg/m^3)],PREVIOUSYEAR(DimDate[Date]))<>blank()) ,divide([Avg. Carbon Monoxide (µg/m^3)], calculate([Avg. Carbon Monoxide (µg/m^3)], PREVIOUSYEAR(DimDate[Date])))-1 , blank()) , blank())
% Variation Nitrogen Dioxide Avg.	Switch(True(), isinscope(DimDate[Month]), if(AND([Avg. Nitrogen Dioxide (µg/m^3)] <> blank(),calculate([Avg. Nitrogen Dioxide (µg/m^3)], PREVIOUSMONTH(DimDate[Date]))<>blank()) ,divide([Avg. Nitrogen Dioxide (µg/m^3)], calculate([Avg. Nitrogen Dioxide (µg/m^3)], PREVIOUSMONTH(DimDate[Date])))-1 , blank()), isinscope(DimDate[Year]), if(AND([Avg. Nitrogen Dioxide (µg/m^3)] <> blank(),calculate([Avg. Nitrogen Dioxide (µg/m^3)], PREVIOUSYEAR(DimDate[Date]))<>blank()) ,divide([Avg. Nitrogen Dioxide (µg/m^3)], calculate([Avg. Nitrogen Dioxide (µg/m^3)], PREVIOUSYEAR(DimDate[Date])))-1 , blank()), blank())

% Variation Ozone Avg.

```
Switch(True(),
isinscope(DimDate[Month]),
   if(
   AND( [Avg. Ozone (μg/m³)] <> blank(),calculate([Avg. Ozone (μg/m³)],
PREVIOUSMONTH(DimDate[Date]))<>blank())
   ,divide([Avg. Ozone (μg/m³)], calculate([Avg. Ozone (μg/m³)], PREVIOUSMONTH(DimDate[Date])))-1
   , blank()),

isinscope(DimDate[Year]),
 if(
   AND( [Avg. Ozone (μg/m³)] <> blank(),calculate([Avg. Ozone (μg/m³)],
PREVIOUSYEAR(DimDate[Date]))<>blank())
   ,divide([Avg. Ozone (μg/m³)], calculate([Avg. Ozone (μg/m³)], PREVIOUSYEAR(DimDate[Date])))-1
   , blank()),


   blank())
```

% Variation Particulate Matter 10 Avg.

```
Switch(True(),
isinscope(DimDate[Month]),
   if(
   AND( [Avg. Particulate Matter 10 (μg/m³)]  <> blank(),calculate([Avg. Particulate Matter 10 (μg/m³)],
PREVIOUSMONTH(DimDate[Date]))<>blank())
   ,divide([Avg. Particulate Matter 10 (μg/m³)], calculate([Avg. Particulate Matter 10 (μg/m³)],
PREVIOUSMONTH(DimDate[Date])))-1
   , blank()),

isinscope(DimDate[Year]),
 if(
   AND( [Avg. Particulate Matter 10 (μg/m³)] <> blank(),calculate([Avg. Particulate Matter 10 (μg/m³)],
PREVIOUSYEAR(DimDate[Date]))<>blank())
   ,divide([Avg. Particulate Matter 10 (μg/m³)], calculate([Avg. Particulate Matter 10 (μg/m³)],
PREVIOUSYEAR(DimDate[Date])))-1
   , blank()),


   blank())
```

% Variation Particulate Matter 2.5 Avg.

```
Switch(True(),
isinscope(DimDate[Month]),
   if(
   AND( [Avg. Particulate Matter 2.5 (μg/m³)]  <> blank(),calculate([Avg. Particulate Matter 2.5 (μg/m³)],
PREVIOUSMONTH(DimDate[Date]))<>blank())
   ,divide([Avg. Particulate Matter 2.5 (μg/m³)], calculate([Avg. Particulate Matter 2.5 (μg/m³)],
PREVIOUSMONTH(DimDate[Date])))-1
   , blank()),

isinscope(DimDate[Year]),
 if(
   AND( [Avg. Particulate Matter 2.5 (μg/m³)] <> blank(),calculate([Avg. Particulate Matter 2.5 (μg/m³)],
PREVIOUSYEAR(DimDate[Date]))<>blank())
   ,divide([Avg. Particulate Matter 2.5 (μg/m³)], calculate([Avg. Particulate Matter 2.5 (μg/m³)],
PREVIOUSYEAR(DimDate[Date])))-1
   , blank()),


   blank())
```

% Variation Sulfur Dioxide Avg.

```
Switch(True(),
isinscope(DimDate[Month]),
   if(
   AND( [Avg. Sulfur Dioxide (μg/m³)]  <> blank(),calculate([Avg. Sulfur Dioxide (μg/m³)] ,
PREVIOUSMONTH(DimDate[Date]))<>blank())
   ,divide([Avg. Sulfur Dioxide (μg/m³)] , calculate([Avg. Sulfur Dioxide (μg/m³)] ,
PREVIOUSMONTH(DimDate[Date])))-1
   , blank()),

isinscope(DimDate[Year]),
 if(
   AND( [Avg. Sulfur Dioxide (μg/m³)]  <> blank(),calculate([Avg. Sulfur Dioxide (μg/m³)] ,
PREVIOUSYEAR(DimDate[Date]))<>blank())
   ,divide([Avg. Sulfur Dioxide (μg/m³)] , calculate([Avg. Sulfur Dioxide (μg/m³)] ,
PREVIOUSYEAR(DimDate[Date])))-1
   , blank()), blank())
```

% Agro-forestry Area

```
divide(Sum([Agro-forestry areas (km²)]),sum([Total Area (km²)]))
```

% Artificial Land Area

```
divide(Sum([Artificial land (km²)]),sum([Total Area (km²)]))
```

% Cropland Area

```
divide(Sum([Cropland area (km²)]),sum([Total Area (km²)]))
```

% Forest Area

```
divide(Sum([Forest area (km²)]),sum([Total Area (km²)]))
```

% Grassland Area

```
divide(Sum([Grassland area (km²)]),sum([Total Area (km²)]))
```

% Open Spaces or Sparce Vegetated Area

```
divide(Sum([Open spaces or sparce vegetated areas (km²)]),sum([Total Area (km²)]))
```

% Shrubland Area

```
divide(Sum([Shrubland area (km²)]),sum([Total Area (km²)]))
```

% Surface Water Bodies Area

```
divide(Sum([Surface water bodies (km²)]),sum([Total Area (km²)]))
```

% Wetlands Area

```
divide(Sum([Wetlands (km²)]),sum([Total Area (km²)]))
```

% Agro-forestry area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and
cover'[Year]),all('Air_Quality_Environment_Percentage of city land area by land use and
cover'),'DimDate'[Year]<d)
return


if(
   and(
   calculate([% Agro-forestry Area],'DimDate'[Year]=p) <>blank()
   ,[% Agro-forestry Area]<>blank())

   ,(
   [% Agro-forestry Area] -
   calculate([% Agro-forestry Area],'DimDate'[Year]=p)
    )*100
    ,blank()
 )
```

% Artificial Land area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and
cover'[Year]),allselected('Air_Quality_Environment_Percentage of city land area by land use and
cover'),'DimDate'[Year]<d)
return

if(
   and(
```

```
    calculate([% Artificial Land area],'DimDate'[Year]=p) <>blank()
    ,[% Artificial Land area]<>blank())

    ,(
    [% Artificial Land area] -
    calculate([% Artificial Land area],'DimDate'[Year]=p)
     )*100
     ,blank()
  )
```

% Cropland area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and
cover'[Year]),allselected('Air_Quality_Environment_Percentage of city land area by land use and
cover'),'DimDate'[Year]<d)
return

if(
    and(
    calculate([% Cropland area],'DimDate'[Year]=p) <>blank()
    ,[% Cropland area]<>blank())

    ,(
    [% Cropland area] -
    calculate([% Cropland area],'DimDate'[Year]=p)
     )*100
     ,blank()
  )
```

% Forest area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and
cover'[Year]),allselected('Air_Quality_Environment_Percentage of city land area by land use and
cover'),'DimDate'[Year]<d)
return

if(
    and(
    calculate([% Forest area],'DimDate'[Year]=p) <>blank()
    ,[% Forest area]<>blank())

    ,(
    [% Forest area] -
    calculate([% Forest area],'DimDate'[Year]=p)
     )*100
     ,blank()
  )
```

% Grassland area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and
cover'[Year]),allselected('Air_Quality_Environment_Percentage of city land area by land use and
cover'),'DimDate'[Year]<d)
return

if(
    and(
    calculate([% Grassland area],'DimDate'[Year]=p) <>blank()
    ,[% Grassland area]<>blank())

    ,(
    [% Grassland area] -
    calculate([% Grassland area],'DimDate'[Year]=p)
     )*100
     ,blank()
  )
```

% Open spaces or sparce vegetated area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and
cover'[Year]),allselected('Air_Quality_Environment_Percentage of city land area by land use and
cover'),'DimDate'[Year]<d)
return

if(
    and(
    calculate([% Open spaces or sparce vegetated area],'DimDate'[Year]=p) <>blank()
    ,[% Open spaces or sparce vegetated area]<>blank())
```

```
    ,(
    [% Open spaces or sparce vegetated area] -
    calculate([% Open spaces or sparce vegetated area],'DimDate'[Year]=p)
     )*100
     ,blank()
  )
```

% Shrubland area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and cover'[Year]),allselected('Air_Quality_Environment_Percentage of city land area by land use and cover'),'DimDate'[Year]<d)
return

if(
    and(
    calculate([% Shrubland area],'DimDate'[Year]=p) <>blank()
    ,[% Shrubland area]<>blank())

    ,(
   [% Shrubland area] -
    calculate([% Shrubland area],'DimDate'[Year]=p)
     )*100
     ,blank()
  )
```

% Surface water bodies area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and cover'[Year]),allselected('Air_Quality_Environment_Percentage of city land area by land use and cover'),'DimDate'[Year]<d)
return

if(
    and(
    calculate([% Surface water bodies area],'DimDate'[Year]=p) <>blank()
    ,[% Surface water bodies area]<>blank())

    ,(
    [% Surface water bodies area] -
    calculate([% Surface water bodies area],'DimDate'[Year]=p)
     )*100
     ,blank()
  )
```

% Wetlands area vs last registry

```
var d = selectedvalue('DimDate'[Year])
var p = calculate(max('Air_Quality_Environment_Percentage of city land area by land use and cover'[Year]),allselected('Air_Quality_Environment_Percentage of city land area by land use and cover'),'DimDate'[Year]<d)
return

if(
    and(
    calculate([% Wetlands area],'DimDate'[Year]=p) <>blank()
    ,[% Wetlands area]<>blank())

    ,(
    [% Wetlands area] -
    calculate([% Wetlands area],'DimDate'[Year]=p)
     )*100
     ,blank()
  )
```

Patents per 100.000 inhab.

```
divide(          Economy_SocialConditions_Indicators[No. Patents],
                 RELATED('Resident Population'[Residents])
                 )   *100000
```

Gini Coefficient vs N-1

```
IF(
    and(
       CALCULATE(
                 SUM('Economy_SocialConditions_Indicators'[Gini Coefficient %]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Economy_SocialConditions_Indicators'[Gini Coefficient %])<>blank()),

     (sum('Economy_SocialConditions_Indicators'[Gini Coefficient %]) -
CALCULATE(SUM('Economy_SocialConditions_Indicators'[Gini Coefficient
```

```
%]),PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

Patents per 100k Residents vs N-1

```
if( and(
      CALCULATE(
                    SUM('Economy_SocialConditions_Indicators'[Patents per 100.000
inhab.]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Economy_SocialConditions_Indicators'[Patents per
100.000 inhab.])<>blank())
,
    sum('Economy_SocialConditions_Indicators'[Patents per 100.000 inhab.])/
CALCULATE(SUM('Economy_SocialConditions_Indicators'[Patents per 100.000
inhab.]),PREVIOUSYEAR(DimDate[Date])) -1,blank())
```

Resident Population at risk of poverty vs N-1

```
IF(
    and(
      CALCULATE(
                    SUM('Economy_SocialConditions_Indicators'[Resident pop at Risk of Poverty
%]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Economy_SocialConditions_Indicators'[Resident pop at
Risk of Poverty %])<>blank()),

    (sum(Economy_SocialConditions_Indicators[Resident pop at Risk of Poverty %]) -
CALCULATE(SUM('Economy_SocialConditions_Indicators'[Resident pop at Risk of Poverty
%]),PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

Survival Rate of Enterprises vs N-1

```
IF(
   and(
      CALCULATE(
                    SUM('Economy_SocialConditions_Indicators'[Survival Rate of Enterprises born 2y before
%]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Economy_SocialConditions_Indicators'[Survival Rate of
Enterprises born 2y before %])<>blank()),

   (sum('Economy_SocialConditions_Indicators'[Survival Rate of Enterprises born 2y before %]) -
CALCULATE(SUM('Economy_SocialConditions_Indicators'[Survival Rate of Enterprises born 2y before
%]),PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

Unemployment Rate vs N-1

```
IF(
    and(
      CALCULATE(
                    SUM('Economy_SocialConditions_Indicators'[Total Unemployment Rate
%]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Economy_SocialConditions_Indicators'[Total
Unemployment Rate %])<>blank()),

   (sum(Economy_SocialConditions_Indicators[Total Unemployment Rate %]) -
CALCULATE(SUM('Economy_SocialConditions_Indicators'[Total Unemployment Rate
%]),PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

Youth Unemployment Rate vs N-1

```
IF(
  and(
      CALCULATE(
                    SUM('Economy_SocialConditions_Indicators'[Youth Unemployment Rate % (15-24
years)]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Economy_SocialConditions_Indicators'[Youth
Unemployment Rate % (15-24 years)])<>blank()),

  (sum(Economy_SocialConditions_Indicators[Youth Unemployment Rate % (15-24 years)]) -
CALCULATE(SUM('Economy_SocialConditions_Indicators'[Youth Unemployment Rate % (15-24
years)]),PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

% Female in Tertiary Ed. vs N-1

```
IF(
    and(
      CALCULATE(
                    SUM('Education_Indicators'[% Female in Tertiary
Ed.]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[% Female in Tertiary
Ed.])<>blank()),

  (sum('Education_Indicators'[% Female in Tertiary Ed.]) - CALCULATE(SUM('Education_Indicators'[% Female
in Tertiary Ed.]),PREVIOUSYEAR(DimDate[Date])
```

```
                         )) *100,BLANK())
```

% Male in Tertiary Ed. vs N-1

```
IF(
   and(
      CALCULATE(
                     SUM('Education_Indicators'[% Male in Tertiary
Ed.]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[% Male in Tertiary
Ed.])<>blank()),

    (sum('Education_Indicators'[% Male in Tertiary Ed.] ) - CALCULATE(SUM('Education_Indicators'[% Male in
Tertiary Ed.]),PREVIOUSYEAR(DimDate[Date])

                         )) *100,BLANK())
```

Completion Rate Primary Ed. vs N-1

```
IF(
   and(
      CALCULATE(
                     SUM('Education_Indicators'[Completion Rate Primary
Ed.]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[Completion Rate Primary
Ed.])<>blank()),

   (sum('Education_Indicators'[Completion Rate Primary Ed.]) -
CALCULATE(SUM('Education_Indicators'[Completion Rate Primary Ed.]),PREVIOUSYEAR(DimDate[Date])

                         )) *100,BLANK())
```

Completion Rate Secondary Ed. vs N-1

```
IF(
   and(
      CALCULATE(
                     SUM('Education_Indicators'[Completion Rate Secondary
Ed.]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[Completion Rate Secondary
Ed.])<>blank()),

    (sum('Education_Indicators'[Completion Rate Secondary Ed.]) -
CALCULATE(SUM('Education_Indicators'[Completion Rate Secondary Ed.]),PREVIOUSYEAR(DimDate[Date])

                         )) *100,BLANK())
```

Females Enrolled Tertiary Ed. vs N-1

```
IF(
  and(
      CALCULATE(
                     SUM('Education_Indicators'[Females Enrolled Tertiary Ed.
(No)]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[Females Enrolled Tertiary Ed.
(No)])<>blank()),

    (sum('Education_Indicators'[Females Enrolled Tertiary Ed. (No)]) /
CALCULATE(SUM('Education_Indicators'[Females Enrolled Tertiary Ed.
(No)]),PREVIOUSYEAR(DimDate[Date])

                         ))-1 ,BLANK())
```

Males Enrolled Tertiary Ed. vs N-1

```
IF(
   and(
      CALCULATE(
                     SUM('Education_Indicators'[Males Enrolled Tertiary Ed.
(No)]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[Males Enrolled Tertiary Ed.
(No)])<>blank()),

    (sum('Education_Indicators'[Males Enrolled Tertiary Ed. (No)]) /
CALCULATE(SUM('Education_Indicators'[Males Enrolled Tertiary Ed. (No)]),PREVIOUSYEAR(DimDate[Date])
               ))-1 ,BLANK())
```

var Avg. Students non-tertiary per computer N-1

```
IF(
   and(
      CALCULATE(
                     SUM('Education_Indicators'[Avg. Students non-tertiary per
computer]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[Avg. Students non-
tertiary per computer])<>blank()),

    (sum('Education_Indicators'[Avg. Students non-tertiary per computer]) -
CALCULATE(SUM('Education_Indicators'[Avg. Students non-tertiary per
computer]),PREVIOUSYEAR(DimDate[Date])
```

```
)) ,BLANK())
```

var Graduates Tertiary Ed. per 1000 hab. vs N-1

```
IF(
  and(
     CALCULATE(
                 SUM('Education_Indicators'[Graduates Tertiary Ed. per 1000
hab.]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[Graduates Tertiary Ed. per
1000 hab.])<>blank()),

    (sum('Education_Indicators'[Graduates Tertiary Ed. per 1000 hab.]) -
CALCULATE(SUM('Education_Indicators'[Graduates Tertiary Ed. per 1000
hab.]),PREVIOUSYEAR(DimDate[Date])

                              )) ,BLANK())
```

var Primary Ed. Student/Teacher Ratio vs N-1

```
IF(
   and(
     CALCULATE(
                 SUM('Education_Indicators'[Primary Ed. Student/Teacher
Ratio]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Education_Indicators'[Primary Ed. Student/Teacher
Ratio])<>blank()),

    (sum('Education_Indicators'[Primary Ed. Student/Teacher Ratio]) -
CALCULATE(SUM('Education_Indicators'[Primary Ed. Student/Teacher
Ratio]),PREVIOUSYEAR(DimDate[Date])

                              )) ,BLANK())
```

% Agriculture Energy cons.

```
divide(sum([Agriculture Energy Cons. (kWh)]),sum([Total kWh Cons.]))
```

% Industry Energy cons.

```
divide(sum([Industry Energy Cons. (kWh)]),sum([Total kWh Cons.]))
```

% Non-Residential Energy cons.

```
divide(sum([Non-residential Energy Cons. (kWh)]),sum([Total kWh Cons.]))
```

% Other Energy cons.

```
divide(sum([Others Energy Cons. (kWh)]),sum([Total kWh Cons.]))
```

% Residential Energy cons.

```
divide(sum([Residential Energy Cons. (kWh)]),sum([Total kWh Cons.]))
```

% Lighting of public buildings Energy cons.

```
divide(sum([Inner lighting of State/public buildings Energy Cons. (kWh)]),sum([Total
kWh Cons.]))
```

% Other Energy Consumptions

```
[% Agriculture Energy cons.] +
[% Industry Energy cons.] +
[% Non-Residential Energy cons.] +
[% Other Energy cons.] +
[% Residential Energy cons.]
```

% Public Road Lighting Energy cons.

```
divide(sum([Lighting of public roads Energy Cons. (kWh)]),sum([Total kWh Cons.]))
```

% Lighting of public buildings cons. vs N-1

```
IF(
   and(
      CALCULATE(
                  [% Lighting of public buildings Energy cons.],PREVIOUSYEAR(DimDate[Date]))<>blank(),[% 
Lighting of public buildings Energy cons.]<>blank()),

    ([% Lighting of public buildings Energy cons.] - CALCULATE([% Lighting of public buildings Energy 
cons.],PREVIOUSYEAR(DimDate[Date])

                        )) *100,BLANK())
```

% Public Road Lighting vs N-1

```
IF(
   and(
      CALCULATE(
                  [% Public Road Lighting Energy cons.],PREVIOUSYEAR(DimDate[Date]))<>blank(),[% Public 
Road Lighting Energy cons.]<>blank()),

   ([% Public Road Lighting Energy cons.] - CALCULATE([% Public Road Lighting Energy 
cons.],PREVIOUSYEAR(DimDate[Date])

                        )) *100,BLANK())
```

Electric Energy kWh/inhab. vs N-1

```
IF(
and(
      CALCULATE(
                  SUM('Energy_Indicators'[Electric Energy kWh/ 
inhab.]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Energy_Indicators'[Electric Energy kWh/ 
inhab.])<>blank()),

    ((sum(Energy_Indicators[Electric Energy kWh/ inhab.])) / CALCULATE(SUM(Energy_Indicators[Electric 
Energy kWh/ inhab.]),PREVIOUSYEAR(DimDate[Date])

                        )) -1,BLANK())
```

Household electric Energy kWh/cons. vs N-1

```
IF(
  and(
      CALCULATE(
                  SUM('Energy_Indicators'[Household Electric Energy 
kWh/cons.]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Energy_Indicators'[Household Electric Energy 
kWh/cons.])<>blank()),

    ((sum(Energy_Indicators[Household Electric Energy kWh/cons.])) / 
CALCULATE(SUM(Energy_Indicators[Household Electric Energy kWh/cons.]),PREVIOUSYEAR(DimDate[Date])

                        )) -1,BLANK())
```

Natural Gas per 1k inhab. vs N-1

```
IF(
 and(
      CALCULATE(
                  SUM('Energy_Indicators'[Natural Gas per 1k inhab. (Nm³ 
thousands)]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Energy_Indicators'[Natural Gas per 1k inhab. 
(Nm³ thousands)])<>blank()),

    ((sum(Energy_Indicators[Natural Gas per 1k inhab. (Nm³ thousands)])) / 
CALCULATE(SUM(Energy_Indicators[Natural Gas per 1k inhab. (Nm³ 
thousands)]),PREVIOUSYEAR(DimDate[Date]))) -1,BLANK())
```

Var. Hosp. Beds per 100k inhab vs N-1

```
IF(
  and(
      CALCULATE(
                  SUM('Health_Indicators'[Hosp. Beds per 100k 
inhab]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Health_Indicators'[Hosp. Beds per 100k 
inhab])<>blank()),

   ((sum(Health_Indicators[Hosp. Beds per 100k inhab])) - CALCULATE(SUM(Health_Indicators[Hosp. Beds 
per 100k inhab]),PREVIOUSYEAR(DimDate[Date])

                        )) ,BLANK())
```

Var. Mortality rate due to suicide per 100k inhab (No.) vs N-1

```
IF(
    and(
      CALCULATE(
                  SUM('Health_Indicators'[Mortality rate due to suicide per 100k inhab 
(No.)]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Health_Indicators'[Mortality rate due to suicide per 
100k inhab (No.)])<>blank()),

   ((sum(Health_Indicators[Mortality rate due to suicide per 100k inhab (No.)])) -
```

```
CALCULATE(SUM(Health_Indicators[Mortality rate due to suicide per 100k inhab
(No.)]),PREVIOUSYEAR(DimDate[Date])

                        )),BLANK())
```

Var. Mortality rate parasitic/infectious dis. per 100k inhab vs N-1

```
IF(
   and(
     CALCULATE(
                  SUM('Health_Indicators'[Mortality rate parasitic/infectious dis. per 100k
inhab]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Health_Indicators'[Mortality rate
parasitic/infectious dis. per 100k inhab])<>blank()),

  ((sum(Health_Indicators[Mortality rate parasitic/infectious dis. per 100k inhab])) -
CALCULATE(SUM(Health_Indicators[Mortality rate parasitic/infectious dis. per 100k
inhab]),PREVIOUSYEAR(DimDate[Date])

                        )),BLANK())
```

Var. Under-Five Mortality per 1000 live births (No.) vs N-1

```
IF(
    and(
     CALCULATE(
                  SUM('Health_Indicators'[Under-Five Mortality per 1000 live births
(No.)]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Health_Indicators'[Under-Five Mortality per 1000
live births (No.)])<>blank()),

   ((sum(Health_Indicators[Under-Five Mortality per 1000 live births (No.)])) -
CALCULATE(SUM(Health_Indicators[Under-Five Mortality per 1000 live births
(No.)]),PREVIOUSYEAR(DimDate[Date])

                        )),BLANK())
```

Variation Expected Years

```
var A = SUM('Health_Life Expectancy at birth'[Expected Years])
var B = LOOKUPVALUE('Health_Life Expectancy at birth'[Expected Years],'Health_Life Expectancy at
birth'[Index],selectedvalue('Health_Life Expectancy at birth'[Index])+1)


return
if(isblank(B),0,A - B )
```

Fire Brigades per 100k Inhab.

```
divide(sum('Safety_Indicators'[Number of Fire Brigades]),(sum('Resident
Population'[Residents])/100000),blank())
```

Firemen per 100k Inhab.

```
divide(sum('Safety_Indicators'[Number of Firemen]),(sum('Resident
Population'[Residents])/100000),blank())
```

Homicides per 100k Inhab.

```
divide(sum('Safety_Indicators'[Number of Homicides]),(sum('Resident
Population'[Residents])/100000),blank())
```

Var. Crime Rate vs N-1

```
IF(
   and(
     CALCULATE(
                  SUM('Safety_Indicators'[Crime Rate
(‰)]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Safety_Indicators'[Crime Rate (‰)])<>blank()),

  ((sum('Safety_Indicators'[Crime Rate (‰)])) - CALCULATE(SUM('Safety_Indicators'[Crime Rate
(‰)]),PREVIOUSYEAR(DimDate[Date])

                        )) ,BLANK())
```

Var. Fire Brigades vs N-1

```
IF(
  and(
     CALCULATE(
                  [Fire Brigades per 100k Inhab.],PREVIOUSYEAR(DimDate[Date]))<>blank(),[Fire Brigades per
100k Inhab.]<>blank()),

   (([Fire Brigades per 100k Inhab.]) - CALCULATE([Fire Brigades per 100k
Inhab.],PREVIOUSYEAR(DimDate[Date])

                        )) ,BLANK())
```

Var. Firemen vs N-1	IF(and(CALCULATE([Firemen per 100k Inhab.],PREVIOUSYEAR(DimDate[Date]))<>blank(),[Firemen per 100k Inhab.]<>blank()), (([Firemen per 100k Inhab.]) - CALCULATE([Firemen per 100k Inhab.],PREVIOUSYEAR(DimDate[Date]))) ,BLANK())
Var. Homicides vs N-1	IF(and(CALCULATE([Homicides per 100k Inhab.],PREVIOUSYEAR(DimDate[Date]))<>blank(),[Homicides per 100k Inhab.]<>blank()), (([Homicides per 100k Inhab.]) - CALCULATE([Homicides per 100k Inhab.],PREVIOUSYEAR(DimDate[Date]))) ,BLANK())
% Solid waste for energy recovery	divide(sum([Urban waste for Energy recovery (t)]),sum(Waste_Wastewater_Indicators[Total collected solid waste]),blank())
% Solid waste for landfill	divide(sum([Urban Waste for Landfill (t)]),sum(Waste_Wastewater_Indicators[Total collected solid waste]),blank())
% Solid waste for multimaterial recovery	divide(sum([Urban waste for Multimaterial recovery (t)]),sum(Waste_Wastewater_Indicators[Total collected solid waste]))
% Solid waste for organic recycling	divide(sum([Urban waste for Organic recycling (t)]),sum(Waste_Wastewater_Indicators[Total collected solid waste]),blank())
Total Collected Solid Waste per capita (ton)	divide(sum(Waste_Wastewater_Indicators[Total collected solid waste]),sum('Resident Population'[Residents]),blank())
% Solid waste for energy recovery vs N-1	IF(and(CALCULATE([% Solid waste for energy recovery],PREVIOUSYEAR(DimDate[Date]))<>blank(),[% Solid waste for energy recovery]<>blank()), ([% Solid waste for energy recovery] - CALCULATE([% Solid waste for energy recovery],PREVIOUSYEAR(DimDate[Date]))) *100,BLANK())
% Solid waste for landfill vs N-1	IF(and(CALCULATE([% Solid waste for landfill],PREVIOUSYEAR(DimDate[Date]))<>blank(),[% Solid waste for landfill]<>blank()), ([% Solid waste for landfill] - CALCULATE([% Solid waste for landfill],PREVIOUSYEAR(DimDate[Date]))) *100,BLANK())
% Solid waste for multimaterial recovery vs N-1	IF(and(CALCULATE([% Solid waste for multimaterial recovery],PREVIOUSYEAR(DimDate[Date]))<>blank(),[% Solid waste for multimaterial recovery]<>blank()), ([% Solid waste for multimaterial recovery] - CALCULATE([% Solid waste for multimaterial recovery],PREVIOUSYEAR(DimDate[Date]))) *100,BLANK())

% Solid waste for organic recycling vs N-1

```
IF(
   and(
      CALCULATE(
                    [% Solid waste for organic recycling],PREVIOUSYEAR(DimDate[Date]))<>blank(),[% Solid
waste for organic recycling]<>blank()),

    ([% Solid waste for organic recycling] - CALCULATE([% Solid waste for organic
recycling],PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

% Tertiary Level Treated Wastewater vs N-1

```
IF(
   and(
      CALCULATE(
                    SUM('Waste_Wastewater_Indicators'[% Tertiary Level Treated
Wastewater]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Waste_Wastewater_Indicators'[% Tertiary
Level Treated Wastewater])<>blank()),

   (sum('Waste_Wastewater_Indicators'[% Tertiary Level Treated Wastewater]) -
CALCULATE(sum('Waste_Wastewater_Indicators'[% Tertiary Level Treated
Wastewater]),PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

% Urban Waste recycled and reused vs N-1

```
IF(
   and(
      CALCULATE(
                    SUM('Waste_Wastewater_Indicators'[% Urban Waste recycled and
reused]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Waste_Wastewater_Indicators'[% Urban Waste
recycled and reused])<>blank()),

   (sum('Waste_Wastewater_Indicators'[% Urban Waste recycled and reused]) -
CALCULATE(SUM('Waste_Wastewater_Indicators'[% Urban Waste recycled and
reused]),PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

Index wastewater sanitation services % vs N-1

```
IF(
    and(
      CALCULATE(
                    SUM('Waste_Wastewater_Indicators'[Index wastewater sanitation services
%]),PREVIOUSYEAR(DimDate[Date]))<>blank(),SUM('Waste_Wastewater_Indicators'[Index wastewater
sanitation services %])<>blank()),

   (sum('Waste_Wastewater_Indicators'[Index wastewater sanitation services %]) -
CALCULATE(sum('Waste_Wastewater_Indicators'[Index wastewater sanitation services
%]),PREVIOUSYEAR(DimDate[Date])

                              )) *100,BLANK())
```

Total Collected Solid Waste per capita (ton) vs N-1

```
IF(
and(
      CALCULATE(
                    [Total Collected Solid Waste per capita
(ton)],PREVIOUSYEAR(DimDate[Date]))<>blank(),[Total Collected Solid Waste per capita (ton)]<>blank()),

    (([Total Collected Solid Waste per capita (ton)]) / CALCULATE([Total Collected Solid Waste per capita
(ton)],PREVIOUSYEAR(DimDate[Date])

                              ))-1 ,BLANK())
```

var Total Collected Solid Waste per capita (ton) vs N-1

```
IF(
and(
CALCULATE(
                    [Total Collected Solid Waste per capita
(ton)],PREVIOUSYEAR(DimDate[Date]))<>blank(),[Total Collected Solid Waste per capita (ton)]<>blank()),

    (([Total Collected Solid Waste per capita (ton)]) - CALCULATE([Total Collected Solid Waste per capita
(ton)],PREVIOUSYEAR(DimDate[Date])        )) ,BLANK())
```