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Mapping SDG 11 in Alto Minho Region – Sustainable cities and communities

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Abstract. The Sustainable Development Goals (SDG) are crucial to aid our society to develop, becoming more sustainable, and building a greater community. More than 200 indicators present in the 17 SDGs follow an Agenda for Sustainable Development for 2030 to make better changes, such as decreasing poverty and hunger; providing better health care and quality education for everyone; eliminating gender inequality; helping communities to grow economically, and build a better, greener, and safer society. In this study, the focus is on SDG 11 - Sustainable cities and communities – with in-depth research in the Alto Minho region, Portugal. The main purpose is to evaluate if the different municipalities in this region are indeed achieving the goals set by SDG 11, by using software such as IBM SPSS, to compare its data. The results referring to the North region of Portugal are not promising, due to the small progress noted in each studied indicator. It has some good progress in some indicators such as 11.3 (Municipal expenditure on cultural heritage per inhabitant) but also has some worse progress, namely for indicator 11.2 (Reconstructions completed per 100 new constructions completed). Keeping this trend, the region will not reach the SDG 11 goal by 2030. This kind of analytical study is important to show the level of progress at the moment, and to understand the level of effort that is needed to improve the results in the region.

Keywords: SDG 11; Sustainable cities and communities; Alto Minho; Mapping.

1. Introduction

In recent years, according to DESA [1], the world population has been increasing exponentially, and studies, such as the recent projections by the United Nations indicate that it is to be expected that at this rate, the population should reach 8.5 billion by the year 2030, and by 2100, the number can go as high as 11.2 billion. In order to make a sustainable planet, 17 SDGs were created, so that every nation can implement these innovative measures.

Sustainable Development Goal 11 measures the sustainability development of various cities and communities, conducive to provide affordable and sustainable transportation, housing, and green in public spaces, reduces the outcomes of natural disasters, as well as disaster risk reduction, and a lot more.

According to United Nations [2] as well as UNESCO [3], currently, cities occupy only about 3% of the world's land, but, even this small percentage, is accounted for 60% to 80% of all energy consumption, and responsible for 75% of the world carbon emis-

sions. Although these data may appear very concerning, there is no denying that cities are of immense importance to every community. Their density and networks drive people to be more productive and more creative, been the key to social and economic organizing units, thus bringing people and jobs together, resulting in economic growth.

According to Daniel [4], SDG 11 will play an important role in achieving the SDGs as it has the potential to interconnect with others. An example is the fact that to be effective in inclusive development, the cities have to take into consideration the needs of people with disabilities, as well as other vulnerable groups, thus bringing together the SDG 11 with the SDG 10 that refers to reduce inequalities and ensuring no one is left behind. With this, it is safe to say that to achieve sustainability, there are various factors to consider, such as recognizing and then balancing the trade-offs among the different goals.

In this paper, a set of indicators are analysed to understand the evolution of this SDG at a micro level in the Alto Minho region. Therefore, Section 2 sets out the main contributions of the SDG field, especially SDG11. The methodology used for this research is presented in Section 3, and the main results are shown in Section 4. Finally, the main findings and some limitations of the study are portrayed in Section 5.

2. Literature Review

As stated by BCSD [5] for many years, society tried many ways to improve the quality of living standards, by using industrialization, but, besides all efforts, it was still shown that a lot of countries still had present in their societies extreme case scenarios, such as poverty and pollution. Because of this, it was necessary to take some measures to improve this situation, to have prosperity for sustainability and better quality of living. The main areas of improvement that should be in sync and considered equal are: environmental, social, and economic. So, for these objectives, the Sustainable Development Goals were created.

According to Friedman and Gostin [6] and Shulla and Leal [7], the Sustainable Development Goals are divided into 17 focus areas, focusing on various types of subjects, such as poverty, education, climate, energy, health, gender equality, employment, sustainability and much more. The ambition of these SDG is that they will certainly apply universally to all nations. These SDG were adopted by most countries within the structure of the United Nations, and they have an agenda set for 2030. The goals are an attempt to evolve as communities and to make efforts to a more sustainable, better, and greener world. Although all these SDGs are something that can be a benefit and an asset to all countries, there will be some difficulties, such as collecting all the necessary data for all the analyses, that will be a very significant challenge for the United Nations.

According to PORDATA [8] and Berisha *et al.* [9], SDG 11 stands to renovate, as well as to plan cities, and the rest of places that contain a large number of human beings, in a way that it offers opportunities for everyone. Additionally, it aims to provide access to basic and fundamental services, such as housing, energy, means of transportation and a wide range of green spaces, all of this while reducing very significantly the number of resources used to do so, thus contributing to preserving the planet by not causing a big impact to the environment.

As maintained by ODS LOCAL [10], SDG 11 has a main goal, which is to build sustainable cities and communities, but also it is deconstructed into the following groups: natural and cultural heritage, transport, housing and sustainable urbanization, spatial planning, and security. All these fields are very important in the development of the present SDG because they are fundamental for the well-being of society. One of the objectives is to create greener cities. Therefore, the communities should decrease/avoid pollutant means of transportation (namely cars or planes) and should adopt greater ways of transportation (such as bicycles or even the metro), and at the same time, improve the greener means of transportation, making more charging stations for electric vehicles, or even solar dependent charging stations. Moreover, cities need to have affordable housing, allowing every person to have a dignified place to live, and with sustainable means. The culture and heritage of each society also need to be preserved and shown. To finish, people have the right to feel safe in their cities, not only that but also be safe for eventual newcomers.

In order to measure the achievement of this SDG, it is necessary to create metrics. According to Dashti [11], to create these necessary metrics, there's a guideline, which is produced in a simple process of gathering data of some data sources, for example: Open Street Map, Tehran and Google Earth Engine.

In other perspective, there is also the Big Earth method to achieve similar results, as claimed by Guo *et al.* [12]. This method is significantly more advanced, using tools like Artificial Intelligence and Robotics. To achieve such results, it takes in account aspects like spatiotemporal characteristics, complex visualizations, high correlation and high (multi) dimensionality.

3. Methodology

The Alto Minho region in the Northwest of Portugal was the region selected for this study. It has a total extension of 2,219 km², and have 231 293 inhabitants in 2021, with a population density of 104 inhabitants per km². It comprises ten municipalities, with the city of Viana do Castelo being the administrative city.

3.1. Data: ODS LOCAL

ODS LOCAL [10] is an online public platform whose main purpose is to monitor and demonstrate to the public, the evolution of every municipality on all the Sustainable Development Goals. This monitoring is achieved by the analysis of individual indicators in every single municipality.

The data extracted from this platform concern the 10 municipalities that compose the Alto Minho region, between the years 2015-2020 (Table 1). The selection of these indicators was conditioned to the availability of data that was discretized at the municipal level. There are other credible sources, but the information that is made available is aggregated by region or district, and it is not possible to collect data at municipality level.

Table 1: Indicators used for SDG 11

Indicator	Description	Unit	Base Value	Target Value
11.1	Ratio of rental housing values to income	%	49,2	22,3
11.2	Reconstructions completed per 100 new constructions completed	No.	0	50
11.3	Municipal expenditure on cultural heritage per inhabitant	€/hab.	0	13,8
11.4	Visitors to museums per inhabitant	No.	0	3,3
11.5	Burnt forest area rate	%	5,4	0
11.6	Inhabitants per firefighter	No.	692	126,9
11.7	Proportion of urban waste selectively collected	%	5	25
11.8	Proportion of municipal waste landfilled	%	94,2	51,4
11.9	Urban waste collected per inhabitant	kg/hab.	678	364

Although there are nine indicators available, only eight will be analysed. The indicator 11.1 - Ratio of rental housing values to income, does not have sufficient data like the rest of the indicators, because it only presents information from 2017.

3.2. Software and Mapping

Mapping regions using metric indicators is an important tool for understanding the evolution of a given area. This way, it is possible to identify patterns and trends in different regions, which can inform policy decisions, resource allocation, and investment strategies. Furthermore, the use of metric indicators enables comparisons to be made between different regions, allowing benchmarking, and the setting of targets for improvement. Mapping software is, in short, an application that assists its users in

processing and analyzing data from various types of sources (Indeed Editorial Team [13]). In this project, the software used to develop the following figures was Adobe Illustrator.

4. Results and Discussion

This section presents the information obtained with the mapping tool followed by the analysis and discussion of the results.

4.1. Mapping

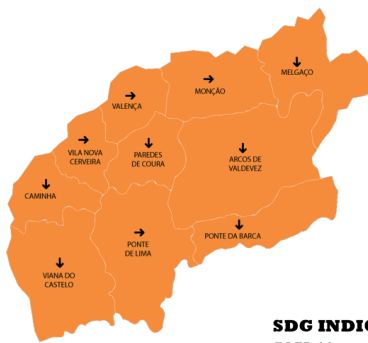
Based on ODSLocal [10] information a set of maps were produced using two types of information (Figure 1). First, it is given information on the municipality in 2020. Four colors were used to describe the status of each municipality concerning the target to be achieved in 2030. Thus:

- The green color means that “the most recent observed value of the municipality has already reached the 2030 target value.” Therefore, it is referred to as “Achieved”.
- The yellow color means that “the most recent observed value of the municipality has not yet reached the target value, but is more than halfway between the base value and the 2030 target value.” Therefore, it is referred to as “Excellent performance”.
- The orange color means that “the most recent observed value of the municipality is better than the baseline value, but is less than halfway between the baseline value and the 2030 target value.” Therefore, is referred to as “Positive performance”.
- The red color means that “the most recent observed value of the municipality falls short of the base value.” Therefore, it is referred to as “Negative performance”.

Additionally, on each map, information is presented on the forecast of each indicator in 2030. Using the data from 2015 to 2020, a linear regression is performed in order to predict the value reached in each indicator if the municipalities maintain the effort trend carried out until now. Additionally, the trend of each municipality was also added, based on data available between 2015 and 2020, as well as a forecasting to 2030, if any additional effort is not done. A set of arrows is defined:

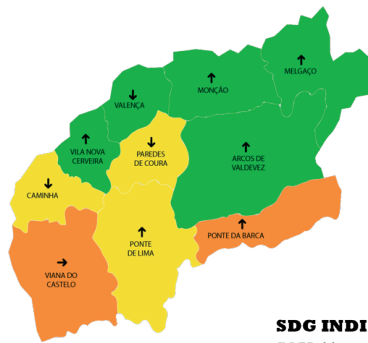
⬆ The up arrow represents the fact that “If the observed trend continues, the municipality will reach the target value by 2030.” Being assigned as “Will reach”.

- The upward arrow represents the fact that “If the observed trend continues, the municipality will not reach the target value, but will be more than halfway between the base value and the 2030 target value.” Being assigned as “Excellent dynamic”.
- ➡ The horizontal arrow represents the fact that “If the observed trend continues, the municipality will not reach the target value, and will be less than halfway between the baseline and the 2030 target value.” Being assigned to “Positive dynamics”.
- ⬇ The down arrow represents the fact that “If the observed trend continues, the municipality will not reach the target value and will fall short of the baseline value in 2030.” Being assigned to “Negative dynamics”



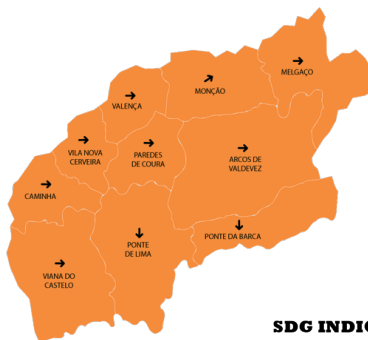
SDG INDICATORS
GOAL 11
INDICATOR 11.2

(a)



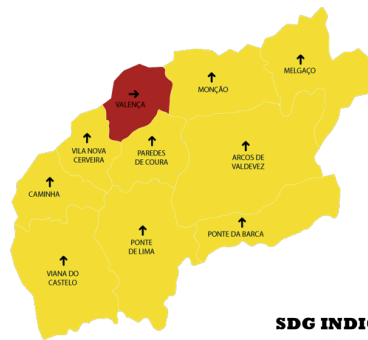
SDG INDICATORS
GOAL 11
INDICATOR 11.3

(b)



SDG INDICATORS
GOAL 11
INDICATOR 11.4

(c)



SDG INDICATORS
GOAL 11
INDICATOR 11.5

(d)

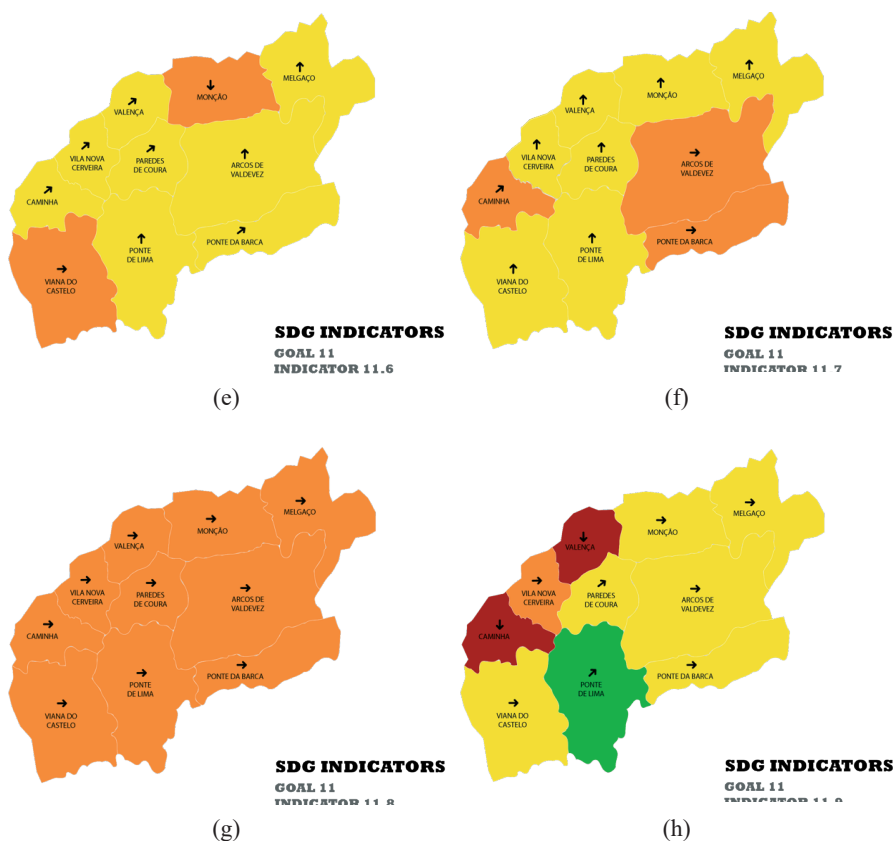


Figure 1 – Alto Minho region: distance to target value and trend evolution for indicators 11.2 (a) to 11.9 (h)

4.2. Analysis and discussion

Starting with SDG 11.2, Alto Minho has an overall positive performance, highlighted with the orange color, but still less than half regarding the baseline value and the target value for 2030. Municipalities like Vila Nova de Cerveira, Ponte de Lima, Valença, and Monção have positive dynamics, shown by the horizontal arrow, which means that if these municipalities continue with this progress, they will not achieve the 2030 goal, but would be less than halfway from it and the baseline. On other hand, all the other municipalities have negative dynamics, displayed by the negative arrow, and are worse than the horizontal arrow, so, if this trend continues, these municipalities will not reach the target value for 2030.

Regarding SDG 11.3, there is a significant difference between the last SDG analyzed, and this one. Shown in green, Vila Nova Cerveira, Valença, Monção, Melgaço, and Arcos de Valdevez have already achieved the target value for 2030. Behind those municipalities in yellow, Caminha, Paredes de Coura, and Ponte de Lima have excellent performances, meaning that although they have not reached the target value, they are more than halfway from it. Finally, with the orange color, Viana do Castelo and Ponte da Barca, show positive performance, but there's a long way to go because it means that these municipalities' values are still less than halfway from the goal. In this indicator, six municipalities are represented with the up arrow, those being Ponte de Lima, Ponte da Barca, Arcos de Valdevez, Melgaço, Monção, and Vila Nova de Cerveira, which means that they will reach the 2030 target value. Viana do Castelo has positive dynamics, and the rest of them have negative dynamics, meaning that there are a lot of areas to improve to reach the desired goal.

Considering the SDG indicator 11.4, Alto Minho's overall distance to target values, has a positive performance. In trend evolution, most of the municipalities have positive dynamics, except Ponte de Lima and Ponte da Barca with negative dynamics, and Monção has an Excellent dynamic, meaning that this municipality is more than halfway between the baseline value and the target value for 2030, but despite this, if this trend continues, the municipality will not reach the 2030 target value.

In the SDG indicator 11.5, which has one concerning municipality in the distance to the target value, Valença, highlighted in red, being in the class of negative performance, meaning that this recent value falls short of the baseline, so, the recent value is not much higher than the baseline. All the other municipalities are yellow, they are more than halfway but there is still a long way to go. Moving on to trend evolution, there is one municipality that has a very different value than the rest, Valença again, in the class of positive dynamics, but despite this, all the other municipalities are represented with the up arrow, thus meaning that if this trend continues, all these municipalities will reach the 2030 target value.

In the indicator 11.6, it is clear that most municipalities are classified as having excellent performance, with only Monção and Viana do Castelo being classified as having Positive Performance. On other hand, in trend evolution, this indicator in Alto Minho, has all the classification's, from an up arrow all the way down to a down arrow, thus bringing a wide spectrum to the analysis. Melgaço, Arcos de Valdevez, and Ponte de Lima will reach the 2030 target value if this trend continues. Valença, Paredes de Coura, Vila Nova de Cerveira, Caminha, and Ponte da Barca, showed with an upward arrow, have excellent dynamics, but there is still room for improvement. To finish this indicator, there's Viana do Castelo with only positive dynamics, and in the worst situation, Monção with negative dynamics.

Regarding the 11.7 indicator, in distance to target value, the number of municipalities with excellent and positive performances are almost the same as indicator 11.6, with this one having two municipalities with a positive performance and 11.7 having three, those being Caminha, Arcos de Valdevez, and Ponte da Barca. Looking at the trend evolution, despite having almost all types of classification, it doesn't have the worst one (down arrow), most municipalities are classified as up arrows, so they will reach the target value, with only Caminha being with excellent dynamics, Arcos de Valdevez and Ponte da Barca with positive dynamics.

From an analysis's perspective, the indicator 11.8 is uniform, the entire Alto Minho's region is shown with orange and the horizontal arrow, it means that the recent value is very poor, better than baseline but not even half of the target. Not only that but if this trend continues, in this indicator, this region in its entirety will not reach the target value.

In the 11.9 indicator, there is a wide range of colors. Starting with the upside, Ponte de Lima already has achieved the target value (Green), but on the opposite side, Caminha and Valença, which are shown in red, still have a lot to improve. Despite this, Vila Nova Cerveira is the only municipality classified as having positive performance, indicated by orange, and all the other's municipalities left have excellent performance. By analyzing the trend evolution, it's visible, again, that Caminha and Valença have negative dynamics, meaning that in conjunction with the negative performance, these two municipalities in this indicator, are likely to not reach the target value. Finally, Ponte de Lima and Paredes de Coura show an excellent dynamic, leaving all the others left with only positive dynamics.

5. Conclusions

To achieve all the goals set for 2030, there are many things that need to be updated, industry needs to adopt ways to become greener and to provide better working and living standards, infrastructures must incorporate means to be more sustainable and safer. To achieve this objective, there are currently several technologies worldwide that will allow it to be fulfilled. Since the implementation of all these SDGs, a lot of countries have cooperated very much in its achievement, and Portugal is one of the countries that is strongly committed, adopting numerous ways to become more sustainable.

By analysing the SDG 11 in Alto Minho's region, it shows some variety in its progress on all indicators, which are weak results to achieve this goal. At this rate, no single municipal will reach the 2030 target value in all indicators. However, it is important to mention that at least in one indicator, there are some municipalities that

will reach the target value. Namely, Arcos de Valdevez, Melgaço, Monção, and Vila Nova de Cerveira in indicator 11.3 (Municipal expenditure on cultural heritage per inhabitant). Additionally, indicator 11.9 (Urban waste collected per inhabitant) has two municipalities which have bad progress, those being Valença and Caminha. After these results, the Region has a long way to go for improvement, for example in indicator 11.3, where some municipalities have very good progress, all other neighboring municipalities, should cooperate in order to progress positively, thus all of them may “join forces” to create good practices and improve the overall progress. But in general, after all the analyses, all municipalities should take into consideration this bad progress, and create measures to improve it, by analyzing the current situation and develop new means and strategies to reach the SDG 11 target value by 2030, thus breaking this trend and improving every aspect of it.

To conclude, Alto Minho’s region in general has good to mediocre progress in this SDG 11, with 11.3 indicator (Municipal expenditure on cultural heritage per inhabitant) being the best indicator, and the worst being 11.2 (Reconstructions completed per 100 new constructions completed), with 11.4 (Visitors to museums per inhabitant) and 11.8 (Proportion of municipal waste landfilled) almost as bad.

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