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Faculdade
de Ciências
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move ▶ green



Sustainable Mobility





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Information

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Turnos

Turno	Semanas	Data	Sala	Turma(s)
PL21	1 - 7, 9 - 14	Qui, 09:00 — 12:00	3.1.10	1MEEA



REQUIREMENTS:

Download QGIS -> <https://qgis.org/en/site/forusers/download.html#>

Dados PORDATA -> <https://www.pordata.pt/>

Data of General Transit Feed Specification (GTFS) -> They can be found on several sources:

<https://www.transporlis.pt/Default.aspx?tabid=314&language=pt-PT>
(new CML website, very organized – start here)

<https://dados.gov.pt/pt/>

http://dados.cm-lisboa.pt/dataset?res_format=GTFS

<https://transitfeeds.com/p/metro-de-lisboa/1003>

We will compile as many of these as we possible can, organize and save them in your folders, the more data the merrier. Sometimes it is hard to find correct or up-to-date data, but we will do our best to find as much Stops data regarding bus, subway, bicycles, boa, tram, etc. to create the most accurate depiction of accessibility to transport possible.



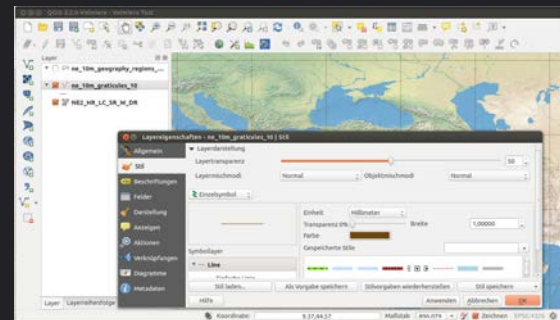
People also ask :

What is QGIS used for?

QGIS (until 2013 known as Quantum GIS) is a free and open-source cross-platform desktop geographic information system (GIS) application that supports **viewing, editing, and analysis of geospatial data.**

<https://en.wikipedia.org/wiki/QGIS>

[QGIS - Wikipedia](#)



Access to mobility services

a Definition

Share of population with appropriate access to mobility services.

b Parameter

Percentage of population living within walking distance of public transport (stop or station) or shared mobility (car or bike) system.

c Methodology description

→ M4: Analysis (spatial data) (using GIS)

The proposed parameter analyses accessibility to mobility services in terms of “the percentage of population living within a public transport service area in a metropolitan area”. This is the percentage of people living within a straight-line distance of 400 meters from a public transport stop (including paratransit such as minibuses) or 800 meters from a rail transport stop. In addition to radial straight-line distance measurements, the real distance measured along the street network can be used too (this is of course more realistic). Values to define the service area based on real distances to be used are 500 meters for bus stops and 1,000 meters for rail stations. If circles based on straight-line distances are used as catchment areas, barriers such as rivers, dams, highways, etc. must be included in order to exclude the areas that are not reachable directly from the public transport stop.

The percentage of people living within the service areas can be calculated by using spatial data – GIS using the Buffer Wizard (e.g. with software ArcGIS and ArcView). The Buffer Wizard allows rings to be drawn around features (points, lines or polygons) at a specified distance from that feature. To use the Buffer Wizard, the map must have defined units; otherwise the buffers cannot be processed. The necessary data are two different shape files, one with public transport stops and one with the population.

d Formula & Calculation method

$$AccI = \frac{\sum_i (PR_i)}{Cap}$$

AccI = Appropriate access Index [% of population]

PR_i = Number of people living within acceptable radius of a station (or stop) of public or shared mode *i* (800 m for train, metro or car sharing station, 400m for bus or tram stop or bike sharing station not yet counted in another mode range [#]

Cap = Capita or number of inhabitants in the city [#]

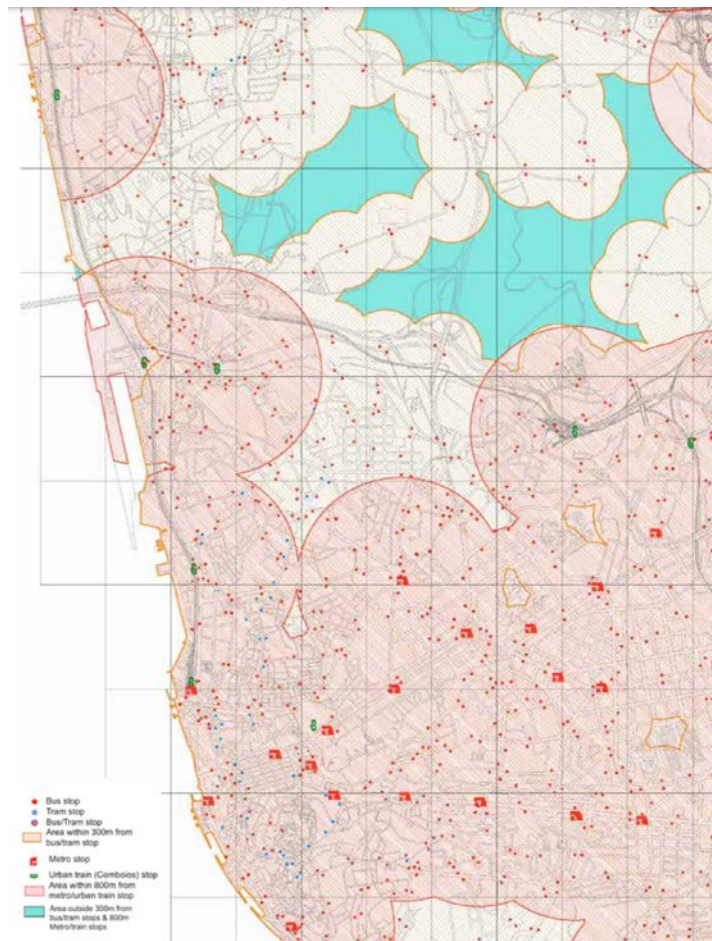


Figure taken from SMP 2.0 Sustainable Mobility Project

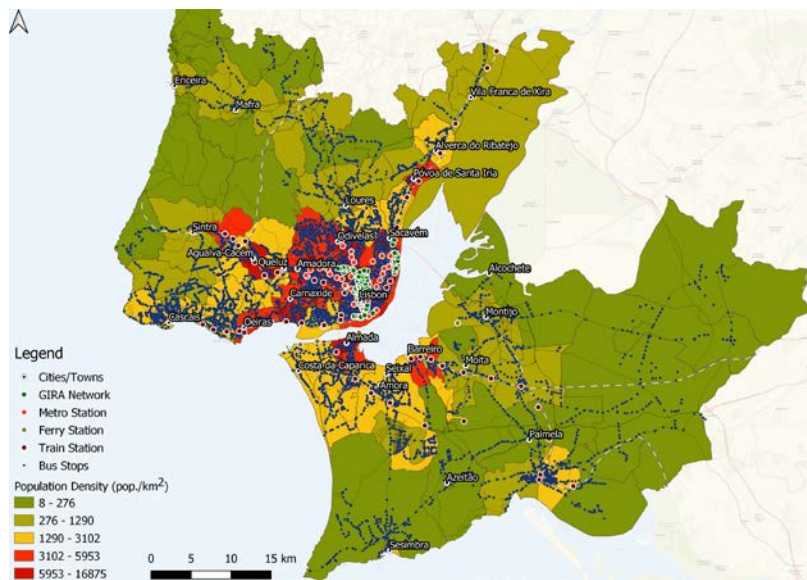


- 2) An alternative approach is to use a 400 m by 400 m grid applied to the city. Within each grid determine the percentage of the total population. Population is given in the most recent City census and may be divided by Ward, Borough, Zone, or other appropriate division. Within each grid identify if there is at least one public transportation stop (bus, metro, train). Enter the data for each grid into the spreadsheet for Indicator “Access”.

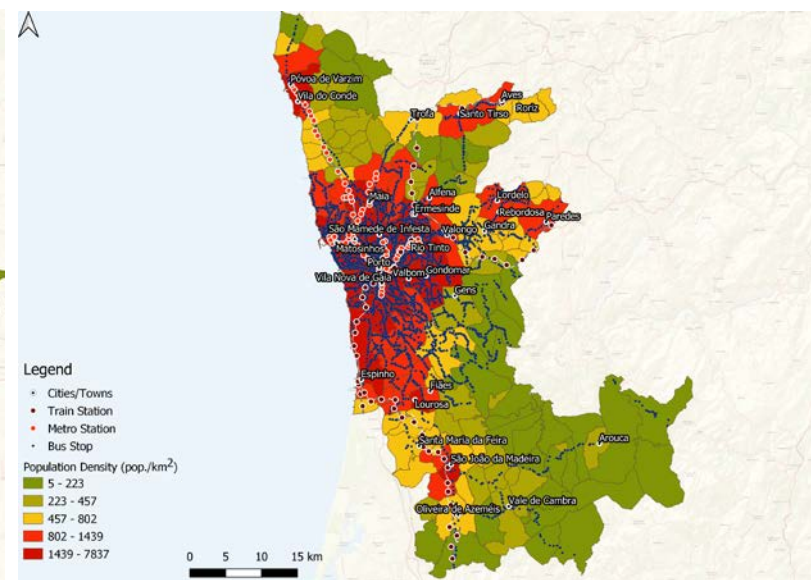
In a perfect world, we would be able to achieve the proposed methodology. However, for this to be a possibility, we would require high grade data which is currently unavailable in Portugal.

Final product similar to:

AML

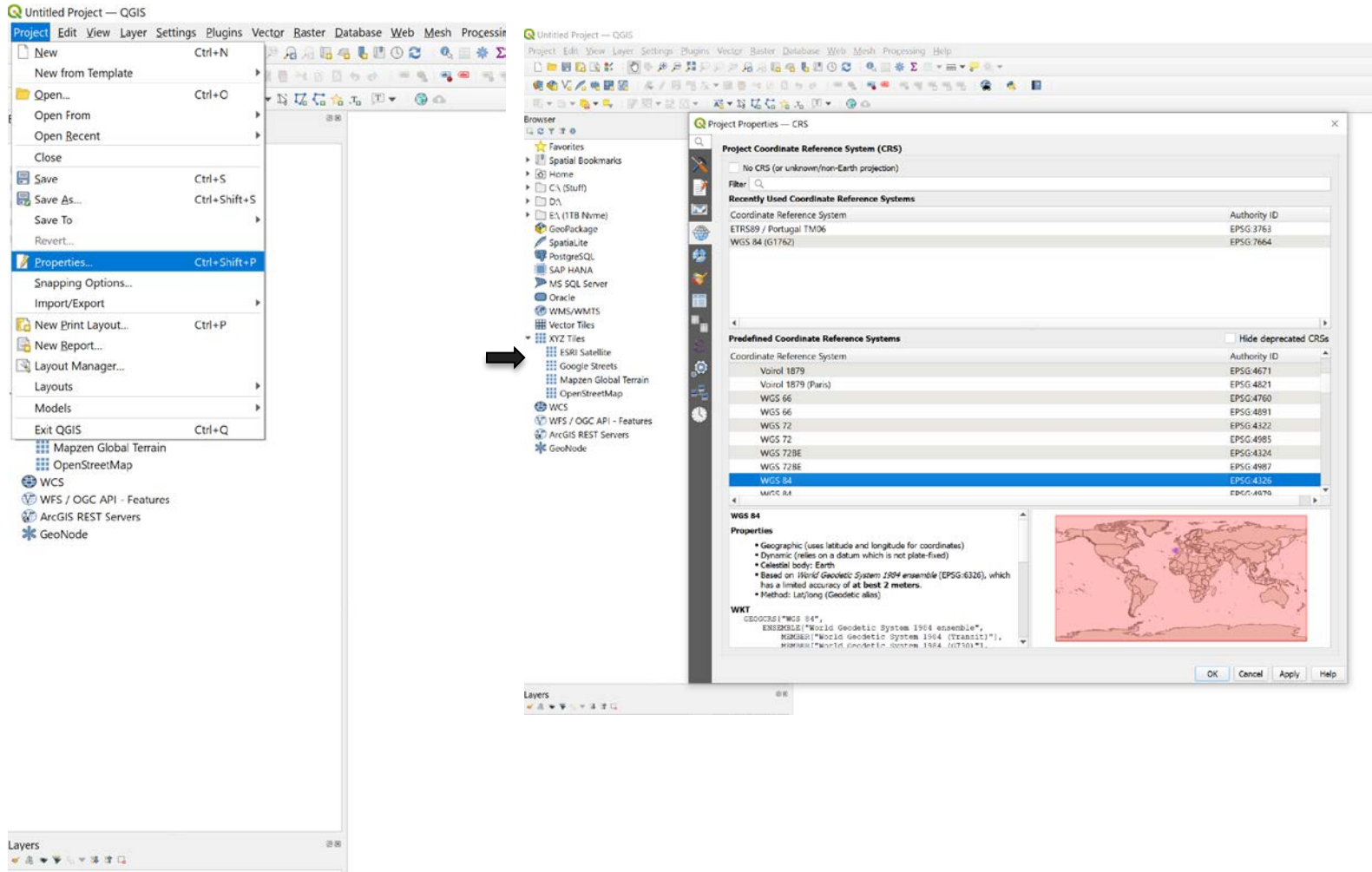


AMP



To get there, let us start.

Make sure you are operating on WGS84. This will be important later.
(Most data we will download uses WGS84 projections)



The screenshot shows the QGIS interface with the 'Project Properties' dialog box open to the 'CRS' tab. The 'Project Coordinate Reference System (CRS)' is set to 'WGS 84 (G1762)'. The 'Recently Used Coordinate Reference Systems' list includes ETRS89 / Portugal TM06 and WGS 84 (G1762). The 'Predefined Coordinate Reference Systems' list includes various systems, with 'WGS 84' selected and highlighted in blue. The 'Properties' section for WGS 84 is visible, showing it is a Geographic CRS based on the World Geodetic System 1984 ensemble.

Project Properties — CRS

Project Coordinate Reference System (CRS)

No CRS (or unknown/non-Earth projection)

Filter:

Recently Used Coordinate Reference Systems

Coordinate Reference System	Authority ID
ETRS89 / Portugal TM06	EPSG:3763
WGS 84 (G1762)	EPSG:7664

Predefined Coordinate Reference Systems Hide deprecated CRSs

Coordinate Reference System	Authority ID
Voiron 1879	EPSG:4671
Voiron 1879 (Paris)	EPSG:4821
WGS 66	EPSG:4760
WGS 66	EPSG:4891
WGS 72	EPSG:4322
WGS 72	EPSG:4985
WGS 72BE	EPSG:4324
WGS 72BE	EPSG:4987
WGS 84	EPSG:4326
WGS 84	EPSG:4978

WGS 84

Properties

- Geographic (uses latitude and longitude for coordinates)
- Dynamic (relies on a datum which is not plate-fixed)
- Celestial body: Earth
- Based on **World Geodetic System 1984 ensemble (EPSG:6326)**, which has a limited accuracy of at best **2 meters**.
- Method: Lat/long (Geodetic alias)

WKT

```
GEOGCS["WGS 84",
  DATUM["World Geodetic System 1984 ensemble",
    SOURCE["World Geodetic System 1984 (Transit)",
      SOURCE["World Geodetic System 1984 (70/10)"]],
  UNIT["meter", 1],
  AXIS["Longitude", EAST],
  AXIS["Latitude", NORTH]]
```



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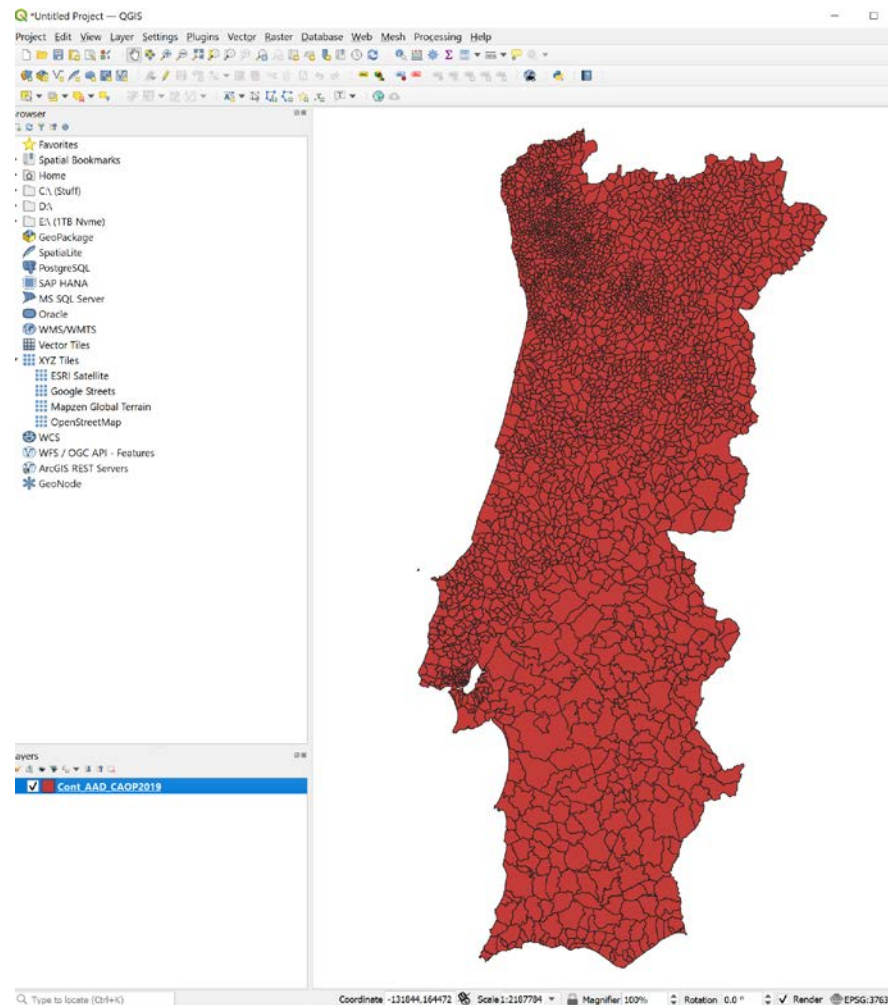
Download the Portuguese CAOP and Load the data:
<https://www.dgterritorio.gov.pt/cartografia/cartografia-tematica/caop?language=en>

The screenshot shows the QGIS interface with the 'Layer' menu open, displaying options like 'Add Layer', 'Copy Style', and 'Open Attribute Table'. The 'Data Source Manager' dialog is open, showing the 'Vector' source type selected. The file path 'Cont_AAD_CAOP2019.shp' is entered in the 'Source' field. The 'Add' button is highlighted with a red box and an arrow, with the text 'Click add' next to it.



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You should know have the map of Portugal loaded. (The colors do not matter, it is random, although later you can change in the layer properties if you want.)





If you open the attribute table of this caop shapefile you just loaded, you'll notice the column "Dicofre". This code represents each "Freguesia" in Portugal. We will now download the population data from INE, prepare the excel file, and join the pop data to this caop through the "Dicofre" column.

The screenshot shows the QGIS interface. On the left, the Layers panel shows 'newLayer_fregs' and 'Cont_AAD_CAOP2019'. A context menu is open over the map, with 'Open Attribute Table' selected. The map displays a red-shaded shapefile of Portugal. Below the map, the attribute table for 'Cont_AAD_CAOP2019' is visible, showing columns for 'Dicofre', 'Freguesia', 'Concelho', 'Distrito', 'TAA', 'AREA_EA_Ha', 'AREA_T_Ha', and 'Des_Simpli'. The table contains 10 rows of data, with the first row selected.

	Dicofre	Freguesia	Concelho	Distrito	TAA	AREA_EA_Ha	AREA_T_Ha	Des_Simpli
1	182415	Freguesias de Vouzela e Paços de Vilhanques	VOUZELA	VEISEU	ÁREA PRINCIPAL	1394.37	1394.37	Vouzela e Paços...
2	182414	União das freguesias de Fataunços e Figueiredo das Donas	VOUZELA	VEISEU	ÁREA PRINCIPAL	1265.97	1265.97	Fataunços e Fig...
3	182413	União das freguesias de Cambra e Carvalhal de Vermilhas	VOUZELA	VEISEU	ÁREA PRINCIPAL	3261.21	3261.21	Cambra e Carval...
4	182411	Ventosa	VOUZELA	VEISEU	ÁREA PRINCIPAL	1833.05	1833.05	Ventosa
5	182410	São Miguel do Mato	VOUZELA	VEISEU	ÁREA PRINCIPAL	900.29	900.29	São Miguel do ...
6	182409	Queirá	VOUZELA	VEISEU	ÁREA PRINCIPAL	2383.47	2383.47	Queirá
7	182407	Fornelo do Monte	VOUZELA	VEISEU	ÁREA PRINCIPAL	1508.10	1508.10	Fornelo do Monte
8	182403	Campia	VOUZELA	VEISEU	ÁREA PRINCIPAL	3926.72	3926.72	Campia
9	182401	Alcofra	VOUZELA	VEISEU	ÁREA PRINCIPAL	2896.27	2896.27	Alcofra
10	182341	Viseu	VEISEU	VEISEU	ÁREA PRINCIPAL	995.99	995.99	Viseu



Download population data from:

The screenshot shows the INE data portal interface. At the top, there is a breadcrumb trail: "Início / Produtos / Base de Dados". Below this, there are navigation tabs: "Principais indicadores", "Principais quadros", "Base de dados" (selected), "Microdados", "Estatísticas territoriais", and "Pirâmides etárias".

Under the "Base de dados" tab, there are four sub-tabs: "Incluir/retirar indicadores", "Alterar condições de seleção" (selected), "Alterar formato do quadro", and "Visualizar quadro".

The main content area displays the selected indicator: "População residente (N.º) por Local de residência, Sexo e Grupo etário; Decenal - INE, Recenseamento da população e habitação - Censos 2021".

On the left, under "Dimensões:", there are four dimensions with expandable options:

- Período de referência dos dados [1]
- Local de residência [125] (selected)
- Sexo [3]
- Grupo etário [1]

Below the dimensions, it shows: "Total de seleções: 130" and "Total de células a visualizar: 375 (permissões:40000)".

On the right, there is a list of municipalities with checkboxes for selection:

- União das freguesias de Cabreiros e Albercaria da Serra
- União das freguesias de Canelas e Espiunca
- União das freguesias de Covelo de Paivó e Janardo
- Urrô
- Várzea
- Espinho
- Espinho
- Paramos
- Silvalde
- União das freguesias de Anta e Gueitim
- Gondomar
- Bagum do Monte (Rio Tinto)

At the top right of the list, there are two options: "Selecionar tudo" (unchecked) and "Limpar seleções" (checked).

At this point you should know how to work with INE and download population data for both AML and AMP.



Create a new excel (make sure it is .csv and add the selected data with freguesias, dicofre and population.

You can name the columns whatever you want, except the “Dicofre”. This column has to have the exact same name as the one in CAOP attribute table.

Período de referência dos dados	Local de residência		Total
		Dicofre	N.º
2021	Alvarenga	010402	1057
	Chave	010407	1270
	Escariz	010409	2114
	Fermedo	010411	1261
	Mansores	010413	1100
	Moldes	010414	1126
	Rossas	010415	1491
	Santa Eulália	010416	2120
	São Miguel do Mato	010417	550
	Tropeço	010418	1086
	União das freguesias de Arouca	010421	5124
	União das freguesias de Cabreir	010422	185
	União das freguesias de Canelas	010423	1065
	União das freguesias de Covelo	010424	171
	Urrô	010419	900
	Várzea	010420	534
	Espinho	010702	10434
	Barcelos	010701	2127

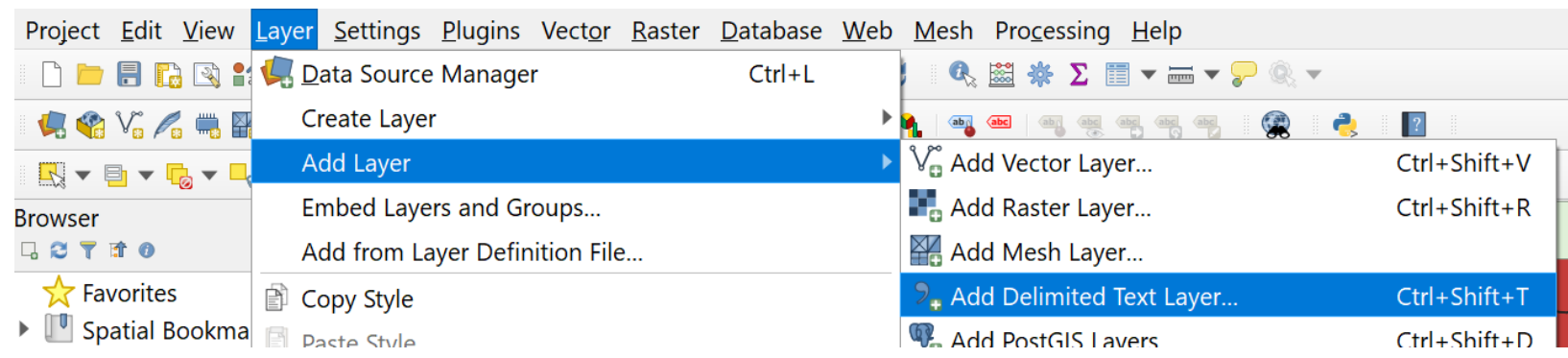
After you create your **filename.csv** with the three columns of freguesias, Dicofre and population, we require an additional step to ensure Qgis reads this .csv properly with the same datatypes as the ones in the CAOP attribute table.

1. Create a **filename.txt**
2. Add the datatype of each column as following:

Assuming you have columns **Freguesias | Dicofre | Population**
You want your .txt to say **“String”,“String”,“Integer”**

3. Save and change the termination of this .txt to .csvt

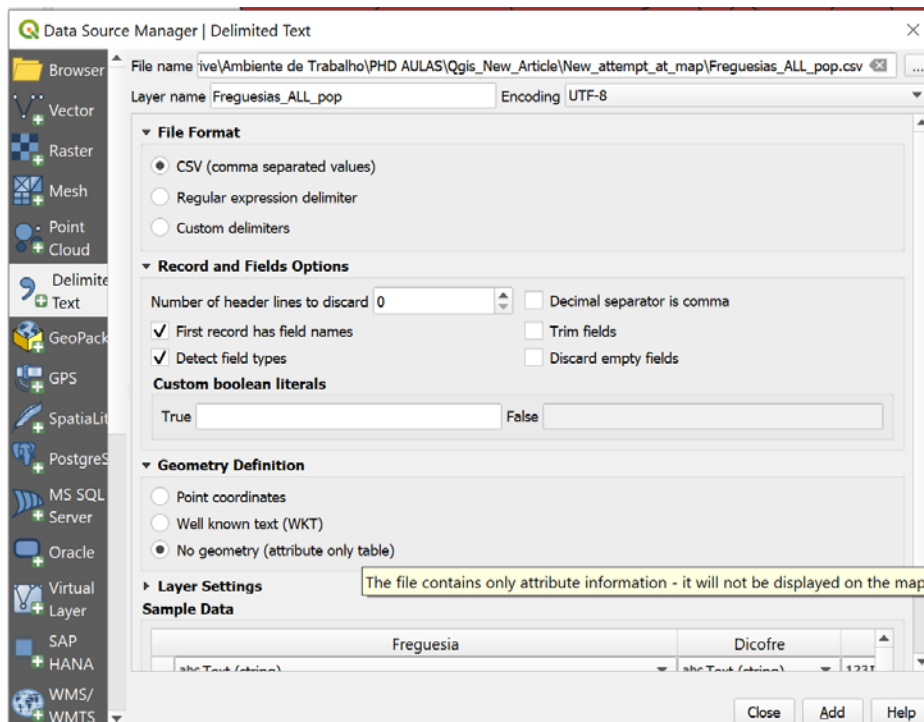
Now you can load your .csv into Qgis so we can proceed with joining this to the CAOP.



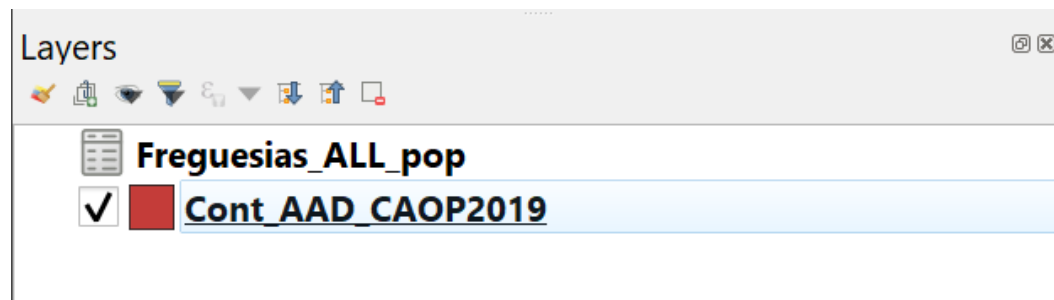


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Add the .csv file as “No geometry”



It should appear in your Layers tab





The JOIN

Zoom to Layer(s)
Zoom to Selection
Show in Overview
Show Feature Count
Show Labels
Copy Layer
Rename Layer
Duplicate Layer
Remove Layer...
Move to Top
Open Attribute Table
Toggle Editing
Filter...
Change Data Source...
Set Layer Scale Visibility...
Layer CRS
Export
Styles
Add Layer Notes...
Properties...

Information
Source
Symbology
Labels
Masks
3D View
Diagrams
Fields
Attributes Form
Joins
Auxiliary Storage
Actions
Display
Rendering
Temporal
Variables
Metadata
Dependencies
Legend
QGIS Server
Digitizing

Layer Properties — Cnt_AAD_CAOP2019 — Joins

Setting Value

Add Vector Join

Join layer: Freguesias_ALL_pc
Join field: abc Dicofre
Target field: abc Dicofre

Cache join layer in memory
 Create attribute index on join field
 Dynamic form
 Editable join layer
 Joined fields

Joined fields:
 Freguesia
 Dicofre
 pop

Custom field name prefix

OK Cancel Help

OK Cancel Apply

Click

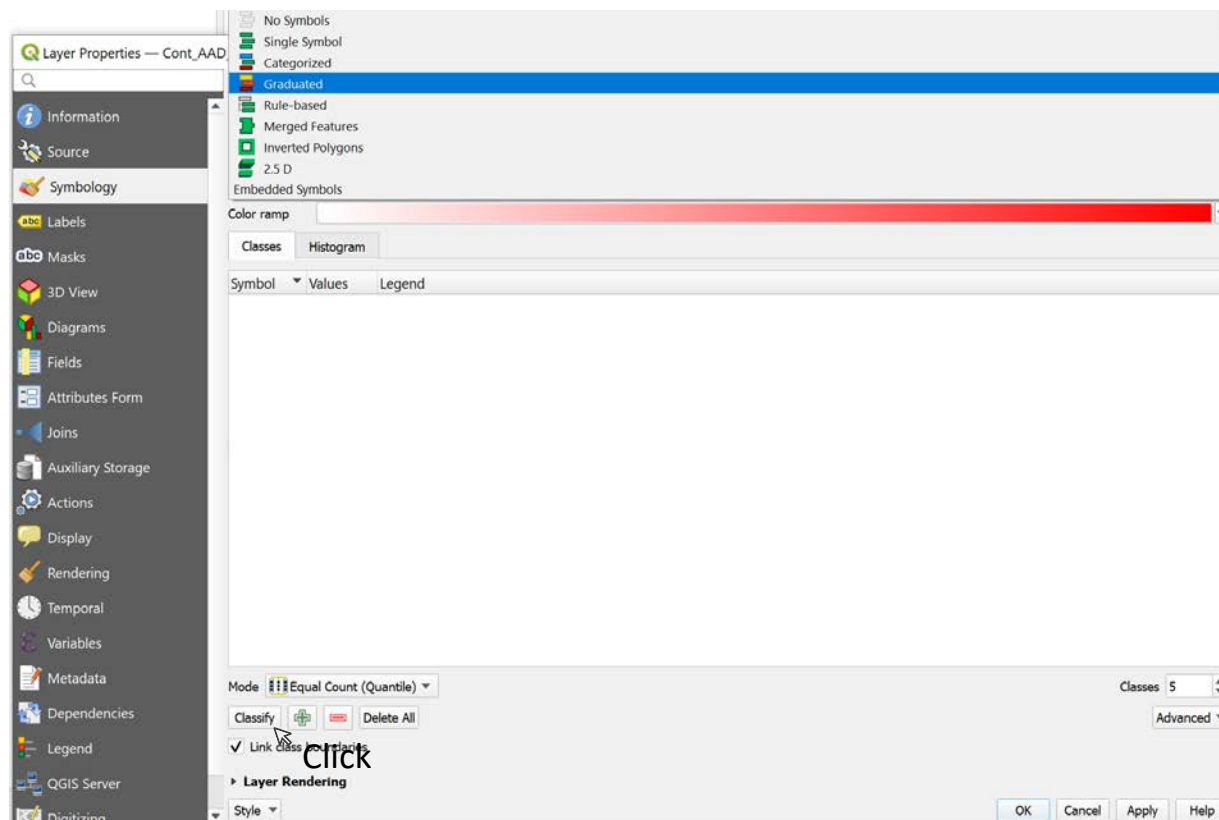
Make sure it looks like this

The only field I want to add is "pop"



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Did it work? Let us isolate the data that we want to show. Go to CAOP properties again but this time select the Symbology Tab:

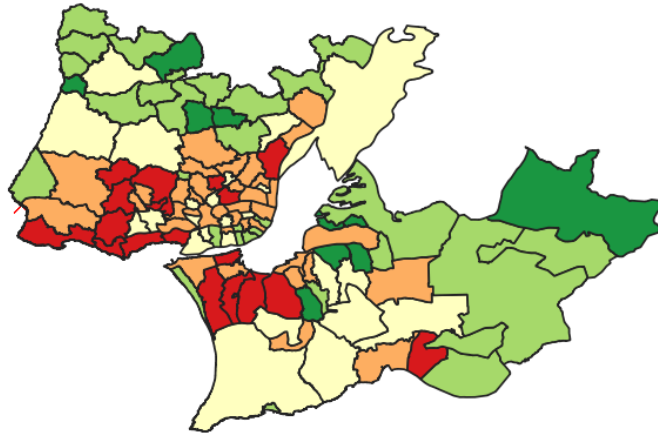
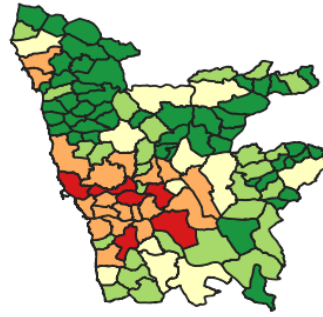


Choose Graduated and whatever color ramp you prefer. Also, make sure in the “Value” field, you put the population attribute. Then click Classify and apply.



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You should have something like this:



Only the matched Dicofre areas have had a population associated with them. So, when we plot the population attribute, we see the pop AML and AMP data we downloaded from INE. We should realize this is total population, it is not taking area into account.



Thus, it would be interesting to see population density, meaning, population per km².

For this, we will use the mathematical capabilities of Qgis.

1. Open the CAOP attribute table.
2. Click on the “Open field calculator) or press Ctrl + i

Dicofre	Freguesia	Dico	Distrito	TAA	AREA_EA_Ha	AREA_T_Ha	Des_Simpli	Freguesias_ALL_pop_pop
140104	Bemposta	ABRANTES	SANTARÉM	ÁREA PRINCIPAL	18745.35	18745.35	Bemposta	NULL
140123	União das freguesias de São Facundo e Vale das Mós	ABRANTES	SANTARÉM	ÁREA PRINCIPAL	10491.24	10491.24	São Facundo e V...	NULL

Field Calculator dialog:

- Only update 1 selected feature(s):
- Create a new field:
- Create virtual field:
- Output field name: Dens_pop
- Output field type: Integer (32 bit)
- Output field length: 10, Precision: 3
- Expression: "Freguesias_ALL_pop_pop" / ("AREA_T_Ha" / 100)

It should look something like this.
Creates a new field dens_pop that is made up of pop / (area_total / 100)

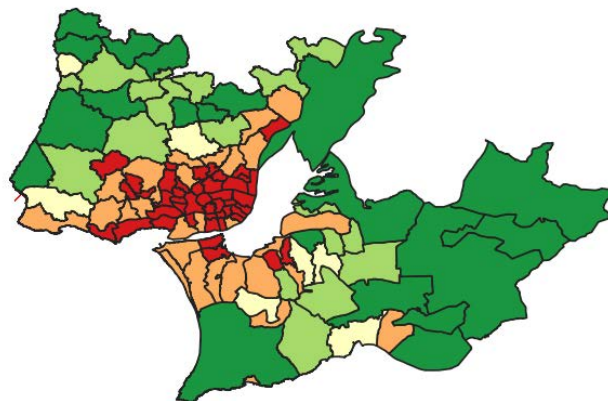
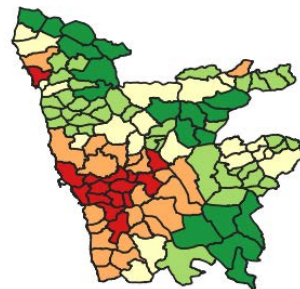
We divide by 100 to transform “Ha” in “km²”.

PS: Use the search function to find freguesias pop and area_t_ha



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Apply the same methodology as in Slide X but this time you will Graduate with the dens_pop value.



The image makes more sense as it reflects the density (pop./km²) instead of just total population.

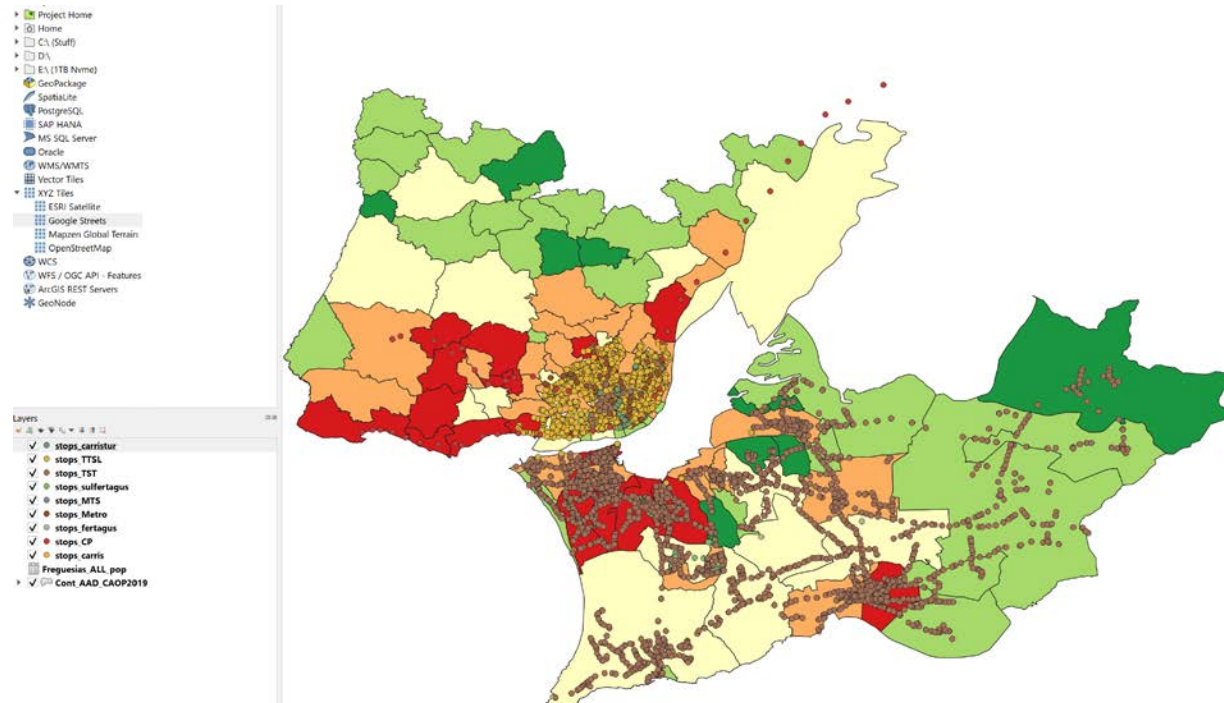


Now that we have population density, we will start filling our map with as much GTFS data as we can possibly find.

Let us start with getting data from

<https://www.transporlis.pt/Default.aspx?tabid=314&language=pt-PT>

Download every single one. We will plot them all. We will try to search other municipalities GTFS data, such as Cascais, Sintra, Odivelas, etc, and plot them.





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We will do the same for AMP. I will make it create a wetransfer link and send you this data along with extra AML data.

Finding data is not always linear, we are at the mercy of institutions, private entities, government entities. In the case of AMP we are lucky there was a hackathon which made available some of this data that I will make available to you.

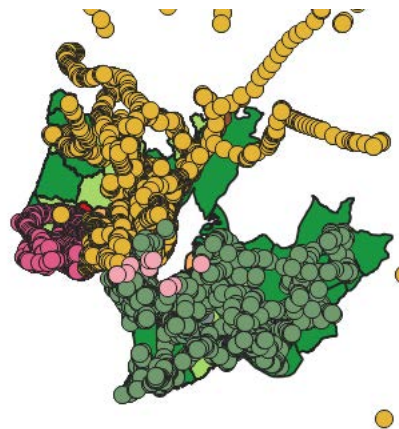
arsoares@fc.ul.pt

After we start populating our map with GTFS information, we should have something like this:

Our layers (we will have more in class if we can.)

- Freguesias
- TTSL
- TST
- stops
- paragens_etr89
- sulfertagus
- metro
- fertagus
- CP
- carristur
- MTS
- Estacoes_metro
- Estacoes_CP
- stops
- carris
- CAOP2020_freguesias
 - 4 - 232
 - 232 - 566
 - 566 - 1186
 - 1186 - 4035
 - 4035 - 16997

AML

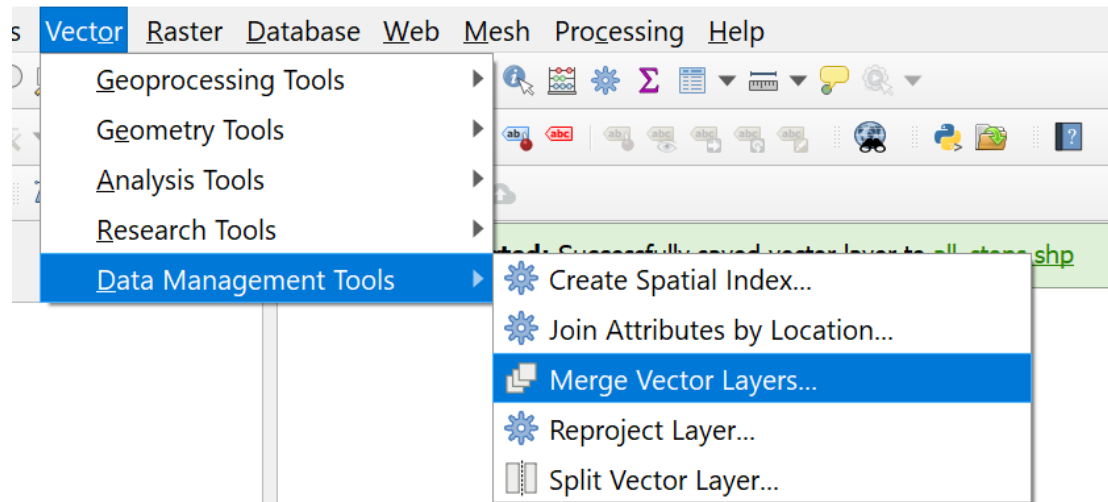


AMP





Merge all Stops layers into one single layer.

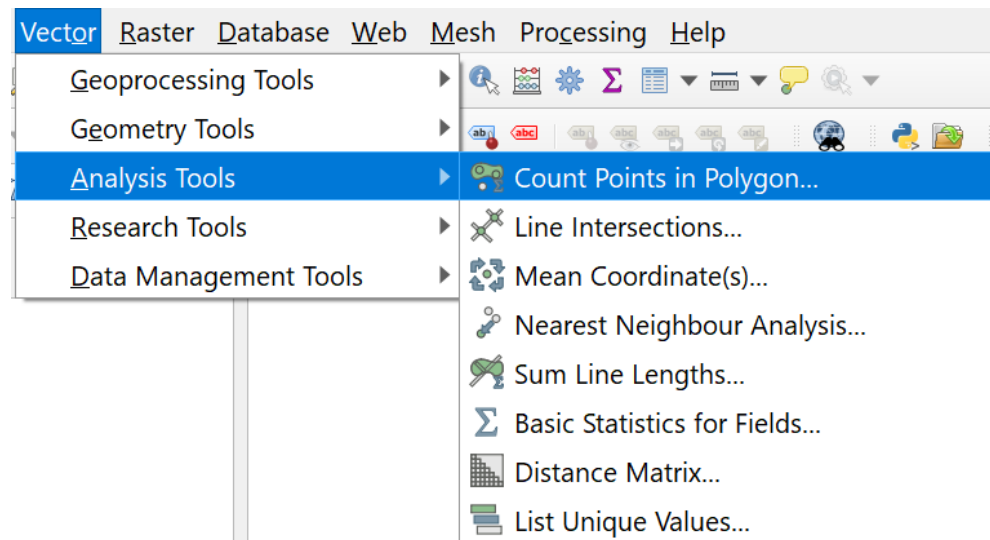




With the new all Stops layer and your CAOP, count Points in polygon...

This will yield a new column in the CAOP attribute table that states how many “Stops” are in each polygon.

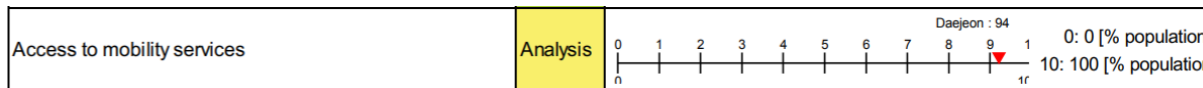
Since we know the population that resides in each polygon, and the area, we can now start calculating how many people have access to this transportation. It is easy to understand how this methodology has its shortcomings and differs from the SMP2.0 methodology, however, this is the best we can do with the data we have available.





The final and most direct way to calculate this indicator is to export the spatial information we have gathered in Qgis, to a .csv

To do so, you will click on the newly created layer which has the Attribute Table with the Counting of the points in each polygon and Export > Save Feature As... Format (comma separated value [CSV]).



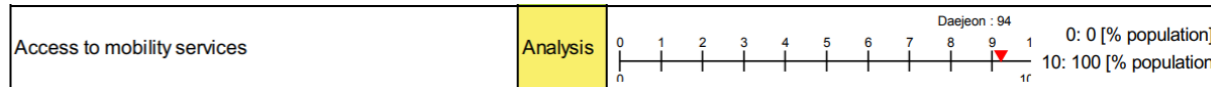
$$AccI = \frac{\sum_i(PR_i)}{Cap}$$

AccI = Appropriate access Index [% of population]

PR_i = Number of people living within acceptable radius of a station (or stop) of public or shared mode *i* (800 m for train, metro or car sharing station, 400m for bus or tram stop or bike sharing station not yet counted in another mode range [#])

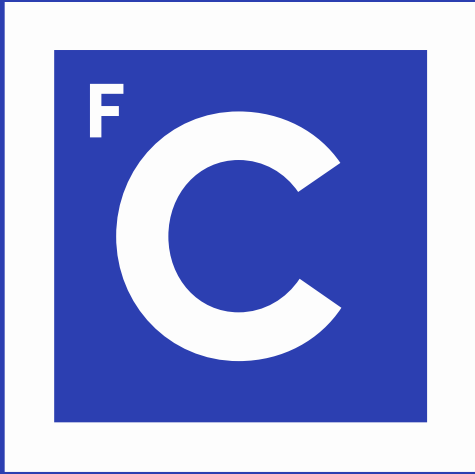
Cap = Capita or number of inhabitants in the city [#]

You should understand by now that we have very limited data to pinpoint in a direct “apples to apples” comparison of the indicator below:



So, we will do a variation of this with the following assumptions:

1. You calculate the best municipality – our 10 in the scale (‘freguesia’ with most stops per capita)
2. Now you compare every other municipality to your 10 and make appropriate averages for both AML and AMP
3. Then you will try to find number of stops per capita for other cities/municipalities in the world to try to convert to our scale for comparison. You have some freedom here but it will award you extra points. It is understandable that you might not find accurate/precise information.



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