# MAKING MEANINGFUL MAPS, WITH QGIS

## An introduction to QGIS: mapping and spatial analysis

*with Alasdair Rae*

**QGIS version:** 3.10 (A Coruña)

**Workbook version and date:** v1.5, February 2021

# Contents

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**A note about QGIS versions**

This workbook was written for QGIS version 3.10.13, the latest long-term release (LTR). If any screenshots in the workbook look different to the ones on your screen it is probably because you're on a different version, or have your toolbars positioned differently, but this is unlikely to cause any problems. Most QGIS versions are named after where the developers have their meetings (e.g. 3.10 is called A Coruña). The LTR version of QGIS is the most stable one, but you will also see a newer version of QGIS on the website – these often have more features but are not yet finalised for official long-term release.

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This workbook is also available online, at:
https://automaticknowledge.org/training/workbooks

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Notes

## About Automatic Knowledge

Our philosophy is all about sharing data and knowledge, so that we can all be a bit better informed about the world. The way we do this is mainly through spatial data analysis and visualisation, and as part of this we offer training courses in geospatial software – mostly QGIS. Alasdair Rae (pictured) founded Automatic Knowledge in 2019 and also runs the training courses.

## Why 'automatic knowledge'?

The idea behind Automatic Knowledge is that we do the hard work of completing the journey from data to knowledge, so that you can then make more informed decisions. These training sessions will hopefully help you do that too.

## Other activities (e.g. free stuff)

In addition to training, we provide a range of consultancy services, specialising in data, spatial analysis, the built environment and cartography. We also publish free and open datasets that you may find useful, at:

automaticknowledge.co.uk/resources

We're also a 'sustaining member' of QGIS, which means that we donate money to the QGIS project on an annual basis, to help fund its development. By taking this course, you're helping too.

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Notes

**Automatic Knowledge training sessions**

The idea behind all our training sessions, and these workbooks, is to help you learn new things in an enjoyable way, without confusing you. We want everyone who takes one of our courses to come away with useful new skills that they can then put into practice in their day-to-day work, and build on in the future.

**About this workbook**

Following a workbook can be a great way to learn new software skills, but there's also a risk that it turns us into robots, following step-by-step instructions in a linear way. During the session we'll go off at tangents and do some demos of useful skills – among other things. *The emojis?* I add them in for a bit of colour, but they also serve a practical purpose because they can help us find key sections of the document quickly.

**Formatting**

Most font is size 14. When switching between screen and workbook this is easier on the eyes. The following format will be used in relation to files/folders, websites, QGIS options/tools, click actions and any text I want you to input. I've also added a 'Notes' section on each page where you can jot things down.

**Files, folders and suchlike:** e.g. world_countries.shp
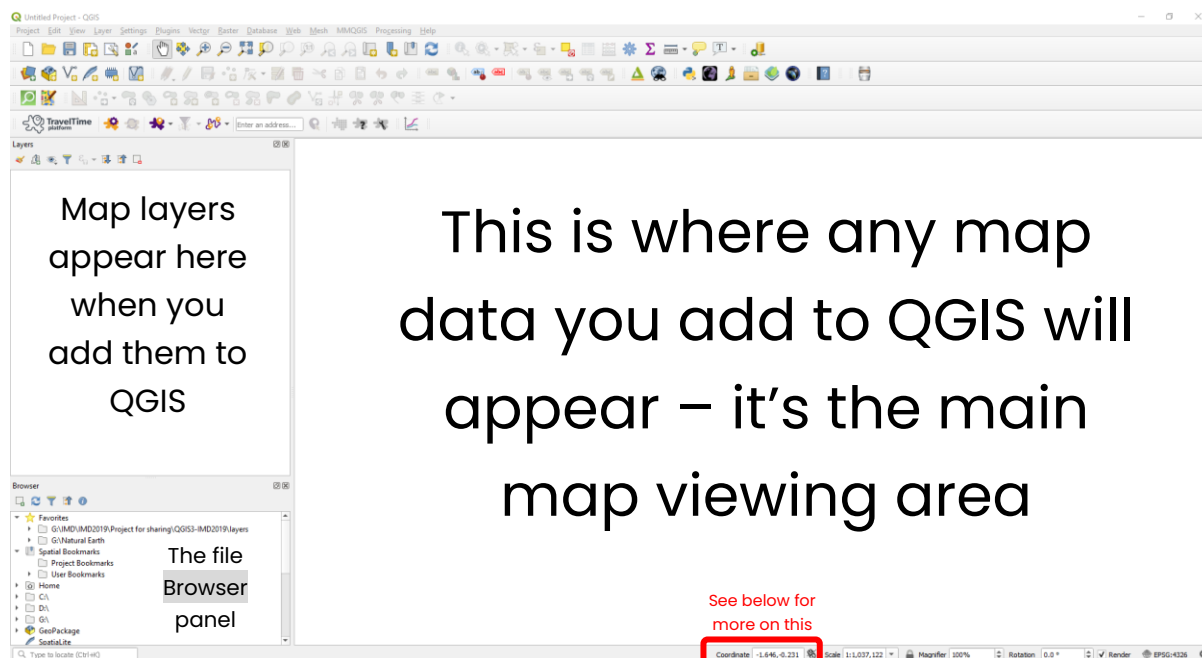**Websites:** e.g. www.automaticknowledge.org/training
**QGIS windows, tools, sections, options:** e.g. Coordinate
**Actions - click menu item/ button:** e.g. Vector > Research Tools
**Text input:** e.g. "geounit" IN ('Japan','New Zealand')

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Notes

## 1. Understanding the QGIS interface

Okay, let's begin by starting QGIS (the current version) Once you do, you'll see something like this, below.



Before we have a play with all the buttons and tools, it's useful to add some map data – otherwise it's all a bit dull.

In the next section we're going to add data to QGIS in the proper way but for now we're going to use a little hack to add a world map.

- In the Coordinate box at the bottom of the QGIS window, delete any numbers that are there, then type in world (all lower case) and then press Enter. As if by magic, a world map will appear!

Notes

Now I want you to spend some time getting used to what all the tools do for the next little while. Let's start by changing the map projection.

- Click where it says EPSG:4326 in the bottom right of the screen. Make sure you're on the CRS section to the left of the Project Properties window and then search for robinson in the Filter box and then select World_Robinson from Predefined Coordinate Reference Systems and click OK.

- Now I want you to explore the world map with the Map Navigation Toolbar – spend a few minutes getting used to what they do. If you can't figure out what any of them do, just ask me. Note that if you hover over a tool, you'll see a little tool tip telling you what that tool is or does.



You might have noticed that you can't really do anything with some of the tools just yet, so let's look at the Attributes Toolbar (shown below)
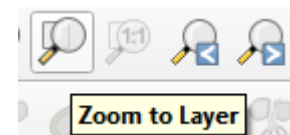




- Make sure you can see your full world map (using the Zoom Full 🔀 button) and then click on the Open Attribute Table 📋 button to see the data behind the map.

Notes

- Click the NAME column header in the Attribute Table to sort from A to Z by country – click it again to reverse the sort.

- Click a row number to highlight a country of your choice. If you pick a tiny country (e.g. Andorra) you may not see the selection (it's highlighted in yellow on the map) so try not to pick a microstate – if you do, just zoom in to see that it is highlighted. Move the table if it is obscuring the map.

This is just a little demonstration of the link between the map view and the data the lies beneath it. With vector-based GIS layers (like the one we're using now) you'll always have an Attribute Table as part of a layer.

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**Top tip – click and drag to zoom**
When you're navigating around maps, you can use the **+** and **–** magnifying glass tools to zoom in by just clicking on them, but you can also click and drag round an area to zoom in or out.

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- Let's make the main map background blue, to look like ocean. Go to the Project menu then Properties... and then in the General section change the Background color to a blue of your choice and then click OK.

Okay, so far, so good. If you're not used to QGIS it can be a bit baffling, but once you know how to navigate your way around a map, select things, and see the Attribute Table it's all much easier. See below for how my screen now looks – hopefully yours looks similar.

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Notes

←The Browser and Layer Styling panels →
can be added via the View > Panels menu
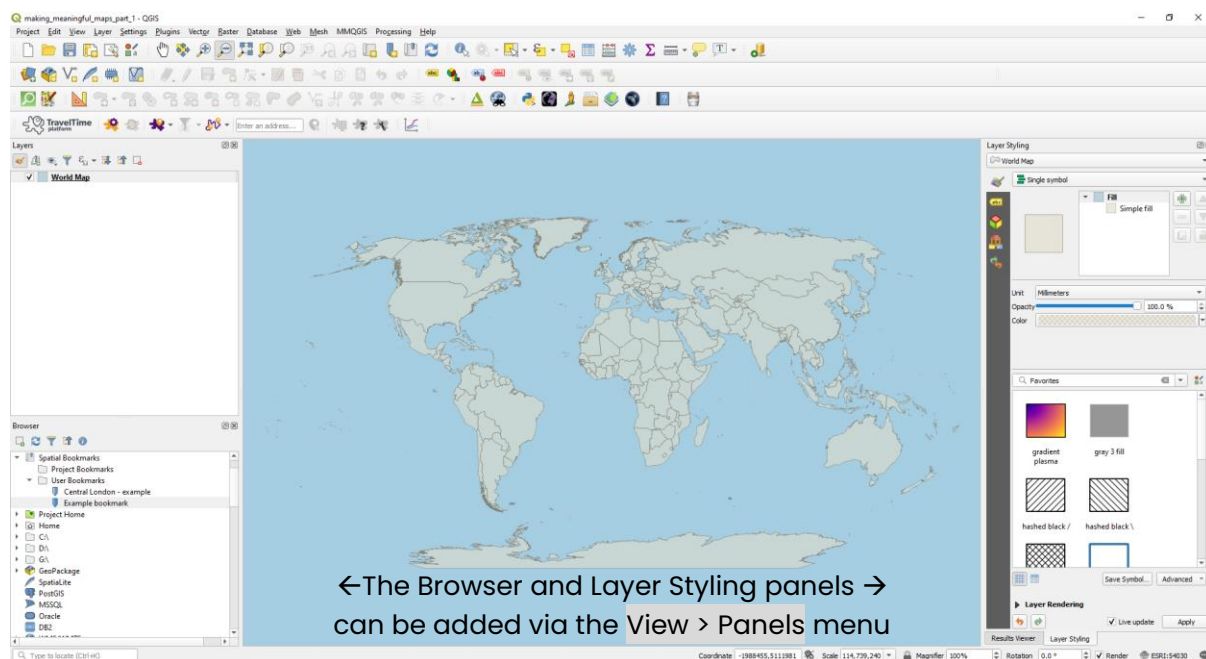
**Time to save your work**
Now's a good time to save your work.

Do this now via Project > Save As… and make sure you save the project somewhere safe and sensible (i.e. not a temp folder!). This saves your work as a QGIS project file (with a qgz file extension). Call the file something like qgis_intro_p6 (then a different page number for future saves). Using incremental saves like this takes up very little disk space (e.g. 25KB) and allows you to go back to different points in the workbook quickly and easily.

Okay, in the next section we're going to add data to QGIS in the way we normally would.

- Start a new project in QGIS by clicking the New Project button now (also available via Project > New) and then go to the next page of the workbook.

Notes

**2. Adding data to QGIS**

The little hack we used to add a world map to QGIS is all very well for a bit of exploring but 99% of the time we'll want to use our own data. For the rest of this training session we'll be using the following three datasets. I'll share the links in a minute.

- A world countries dataset (shapefile and GeoPackage) – this is from naturalearthdata.com and is free, open data.
- A world cities dataset (from a simple text file) – this is from simplemaps.com and is also free, open data.
- A world countries population dataset (from an Excel file) – this is from data.worldbank.org/indicator/SP.POP.TOTL and once again it's free, open data.

Before we add the data to QGIS we first need to download it.

- Go to https://automaticknowledge.org/training/data/ and download datasets 1 to 4. It's best if you put them in the same folder, perhaps one you've created for this session – **just make sure you know where they're saved to**. You'll have to unzip 2_world_countries_shapefile.zip before adding it to QGIS, so don't forget this bit. These are the files you'll get (1 and 2 are different versions of the same data).

- 1_world_countries.gpkg
- 2_world_countries_shapefile.zip (unzip after downloading)
- 3_world_cities.csv (this is just a simple text file)
- 4_world_bank_population_data_1960-2019.xlsx

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Notes

There are loads of ways to get data into QGIS, but the main way is via the Data Source Manager – this lets you add loads of different kinds of data to QGIS.

- Click the Open Data Source Manager 🗂️ button to get started and you'll see the Data Source Manager – just like the screenshot below. Read the text below to add the data.
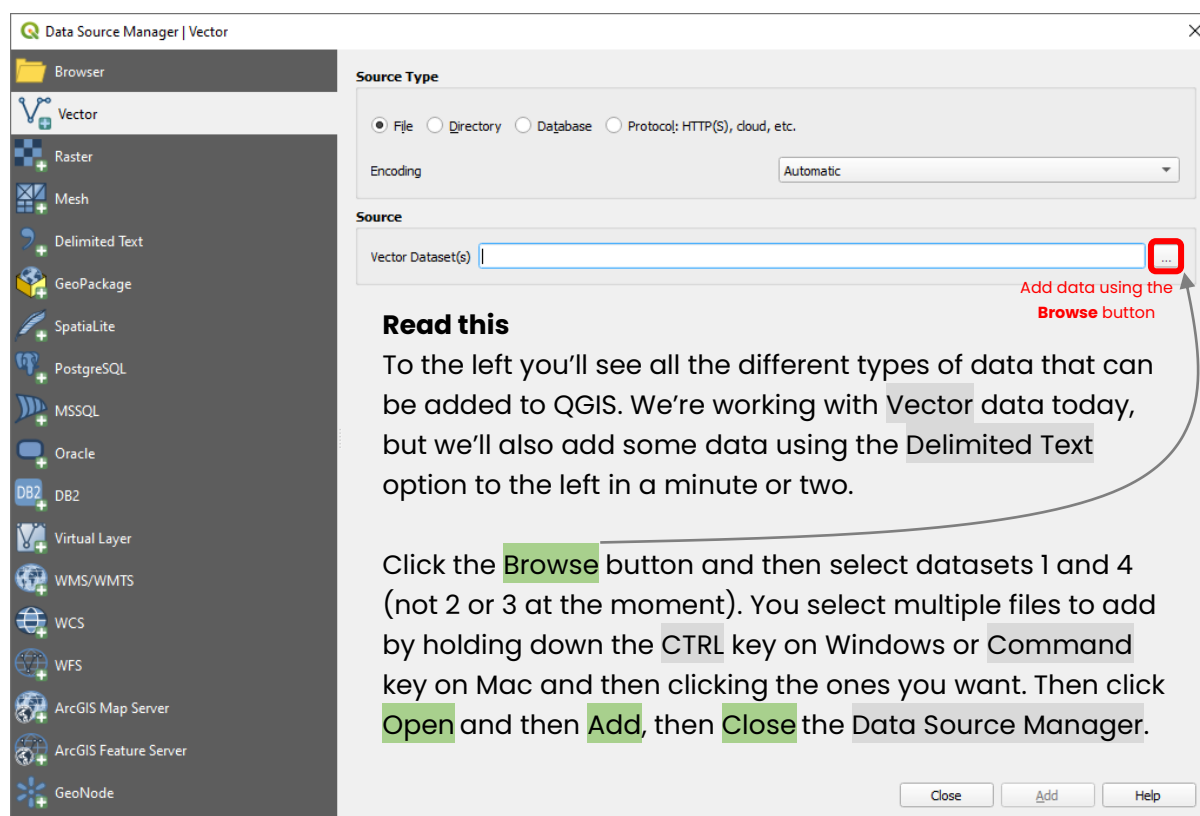


Once you've closed the Data Source Manger you should see a world map on your screen – the colour is randomly assigned by QGIS but we'll fix that later on. You'll also see one other file in the Layers panel on the left but it's just a table, with no map data.

Notes

> **Baffled?**
> If any of this is causing confusion, if you can't download the data, or anything else weird is happening, just let me know and I'll be happy to help.

Okay, so we've added datasets 1 and 4, but what about 2 and 3? Well, let's start by adding in dataset 3, called 3_world_cities.csv. You could just open this file in Excel, Word, TextEdit, Notepad or any other programme that reads text files and you'd see the text shown in the screenshot below. The important thing is that the file contains latitude and longitude data (the lat and lng columns) so we can easily map it in QGIS.

| | city | city_ascii | lat | lng | country | iso2 | iso3 | admin_name | capital | population | id |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Tokyo | Tokyo | 35.6897 | 139.6922 | Japan | JP | JPN | Tōkyō | primary | 37977000 | 1392685764 |
| 2 | Jakarta | Jakarta | -6.2146 | 106.8451 | Indonesia | ID | IDN | Jakarta | primary | 34540000 | 1360771077 |
| 3 | Delhi | Delhi | 28.6600 | 77.2300 | India | IN | IND | Delhi | admin | 29617000 | 1356872604 |
| 4 | Mumbai | Mumbai | 18.9667 | 72.8333 | India | IN | IND | Mahārāshtra | admin | 23355000 | 1356226629 |
| 5 | Manila | Manila | 14.5958 | 120.9772 | Philippines | PH | PHL | Manila | primary | 23088000 | 1608618140 |
| 6 | Shanghai | Shanghai | 31.1667 | 121.4667 | China | CN | CHN | Shanghai | admin | 22120000 | 1156073548 |
| 7 | São Paulo | Sao Paulo | -23.5504 | -46.6339 | Brazil | BR | BRA | São Paulo | admin | 22046000 | 1076532519 |
| 8 | Seoul | Seoul | 37.5833 | 127.0000 | Korea, South | KR | KOR | Seoul | primary | 21794000 | 1410836482 |
| 9 | Mexico City | Mexico City | 19.4333 | -99.1333 | Mexico | MX | MEX | Ciudad de México | primary | 20996000 | 1484247881 |

- Click the Open Data Source Manager button again and this time, via the Delimited Text option on the left, navigate to the 3_world_cities.csv file via the Browse button and then click Open.

- Don't worry about all the options, we only need to change a few things. In the Geometry Definition section just make sure X field is set to lng and Y field is set to lat. This lets QGIS know where to place the points on the map. Once your settings match the ones below, click Add then Close.

Notes
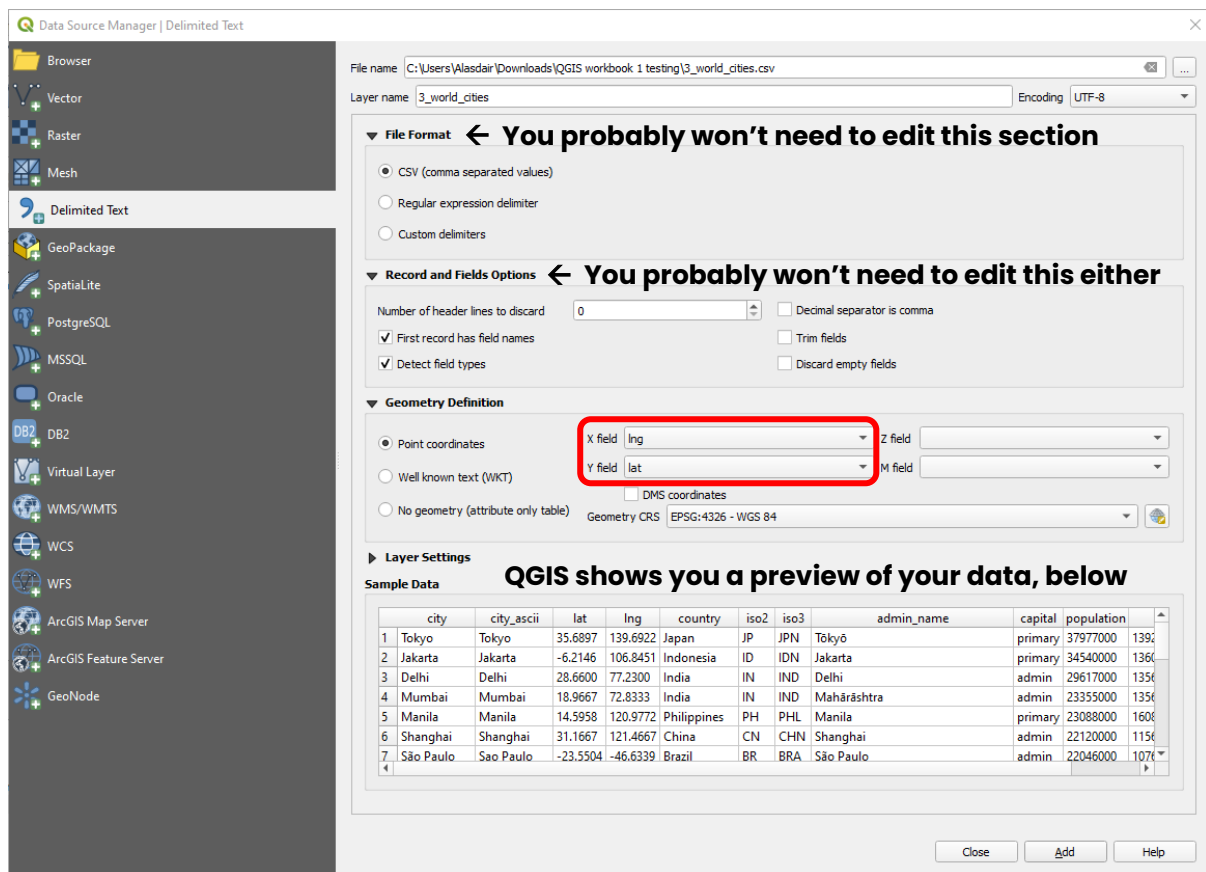
If you've done the last bit right, you'll now see thousands of dots on top of your world map! Yee-ha.

> **Top tip – change layer order with drag and drop**
> If your world cities layer is under your countries layer, it's easy to fix.
> You can re-arrange the order of map layers in the Layers panel on the left by dragging and dropping them up and down. Feel free to try anyway.

- Add dataset 2 now by going to where you saved it on your computer, and then drag and drop 2_world_countries.shp into the map area in QGIS. This is another way to add data to QGIS. Change the layer order if it's on top of the points.

Notes

> **Remember this** ⚠️
>
> There are loads of different file formats when you're working with GIS data. The most common one is the shapefile, but unlike the name suggests a shapefile is not just one single file, but in fact is made up of at least three. A shapefile has a shp part (this stores the geometry), a dbf part (this is the attribute table) and a shx part (an index file). Without all three of these parts it won't work.
>
> The prj part isn't essential but it's often part of the file package and contains the projection information. It's a tried-and-tested file format in GIS and it works well for most people. A more modern equivalent is the GeoPackage – it looks and feels the same but there is just one file, and it's a lot more versatile (e.g. column names can be longer than 10 characters).
>
> At present the GIS world is in a bit of a transition period between the shapefile and the GeoPackage but that doesn't matter much to us today. I just want you to be aware of the different file types – and that for mapping the differences are often negligible.
>
> I prefer to use the GeoPackage because it is cleaner and more versatile.

- Using the Zoom In 🔍 button, click and drag to zoom right in to New Zealand so you can see the country and cities.

- Via Project > Properties.. > General change the Background color to a nice blue again to make it look more like ocean.

> **Time to save your work** 💾
> Save your project – e.g. as qgis_intro_p11 and then head
> to the next page. Remember to save your work regularly as you go
> through the workbook, just in case disaster strikes.

Notes

## 3. Styling data – make it look nice

Use the Zoom Full 🔍 button so that you're looking at the full world, if you aren't already. We're going to make it look nicer, but first we need to do something about all those dots. So, let's take a quick detour into filters.

- Right-click the 3_world_cities layer and select Filter… and you'll see the Query Builder. This allows us to filter our data using an expression, so we only see part of it.

- We'll do more of this later on but for now, in the Fields box, double-click capital and then the = button below Operators and then, with capital selected under Fields), click the All button to see the options. Double-click primary to add it to the expression.

- Once you see "capital" = 'primary' in the expression box you can click Test to check it will work, OK to confirm the query and OK to apply it. See below for how the query should look.



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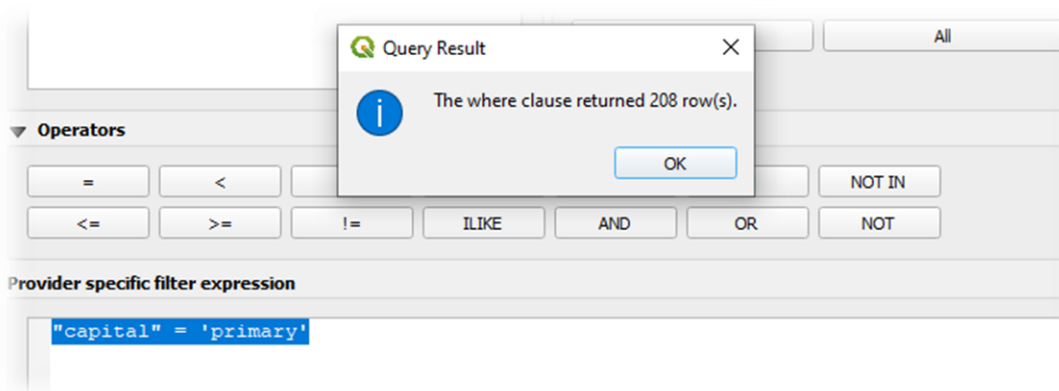
Notes

You now have two map layers with countries, and one with cities. Now it's time to make them look better. You can access the Symbology for a layer by double-clicking it but we'll use the Layer Styling panel in QGIS instead because it's really simple.

- If you don't already have the Layer Styling panel on, activate it via View > Panels > Layer Styling. Once you're there, make sure the top countries layer you can see on the map is the one named at the top of the Layer Styling panel and change the colour of the layer to a nice green colour. We'll style the other country layer later on.

- Using the layer selector dropdown, change to the 3_world_cities layer and change the dots to size 1.5 with a white Color.

- Using the EPSG button (bottom right of the QGIS window), set projection to World_Robinson. Click OK.
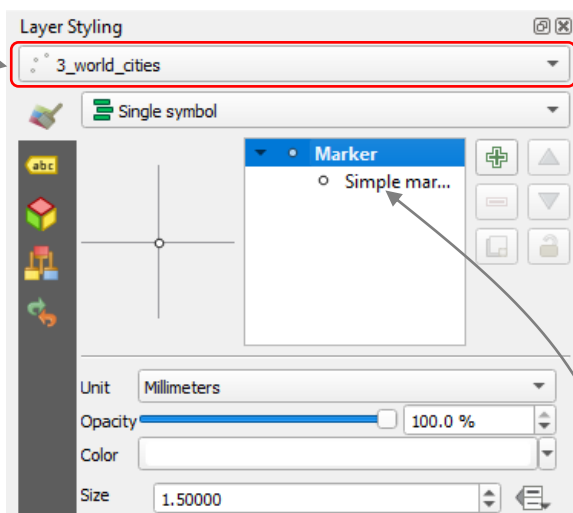
**Top tip**
To change the Stroke color (i.e. the outline) rather than the Fill color for a layer, click where it says Simple marker or Simple fill and you can change its properties. I usually change the Stroke width for polygons to 0.15, rather than the default 0.26 - I find 0.26 a bit thick. Note the Live update tick box and Apply button at the bottom of the Layer Styling panel.

Notes

You'll get better at using all the options in the Layer Styling panel with more practice, but we only have time to focus on the fundamentals today. So, with that in mind, let's add some labels.

- Click the Labels 🔤 icon in Layer Styling for the cities layer and you'll see that it will say No labels.

- I said before that I didn't want to turn anyone into a robot, so have a go at labelling the cities yourself now. To get started, change No labels to Single labels (using city as the label Value) then explore the different label options via the tabs shown below. I've also provided a screenshot of my label setup. I'll do a demo of this shortly.





I'll do a live demo of this so you can follow along

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Notes

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**Follow along demo time**

I want to give you more of an extended insight into labelling in QGIS
because it is so important and it can make or break
a map. We'll look at the following options, via Layer Properties:

Text – using a nice font is super important. So is colour.

Formatting – want to use all UPPER case, or all lower? We can do it all here.

Buffer – this describes the 'halo' or 'glow' around the label lettering.

Background – we can also use a background for our labels.

Shadow – this can be a really nice effect, but you need to be careful.

Callouts – not often needed, but can be really helpful.

Placement – again, this can absolutely make or break a map.

Rendering – this includes things like only seeing labels at some scales.

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Did you notice from the screenshot on the previous page that my coastline had a nice soft glow around it, to kind of ease the contrast between land and sea? Well, that's another useful trick in QGIS – achieved using Draw effects and accessed via Layer Rendering.
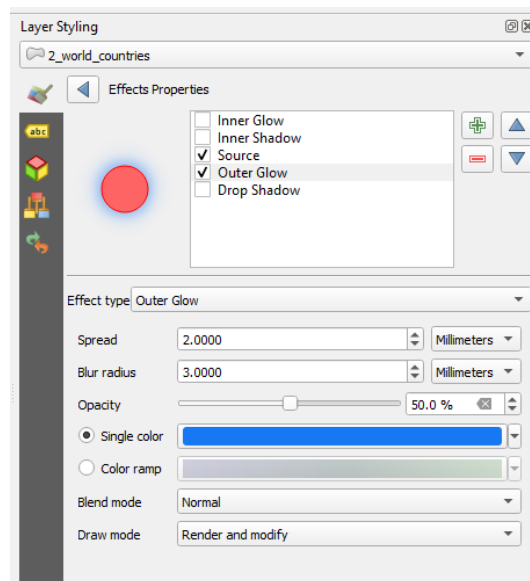
You'll find Layer Rendering at the bottom of the Layer Styling panel, on the Symbology section. Tick the Draw effects box, and then the little star for the settings. You can see the settings I've used in the screenshot above – try and do something similar.
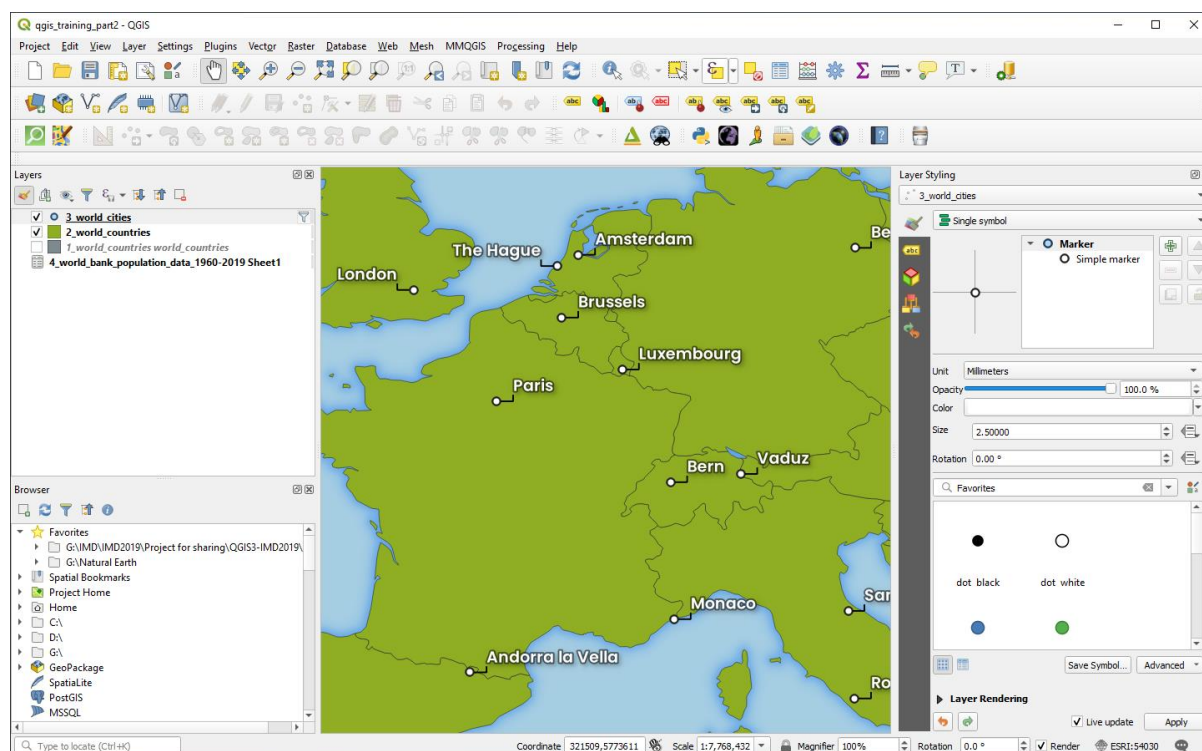
Notes

**Top tip – how to export to a new layer (e.g. shapefile)**
The cities layer you're working with is a text layer that QGIS can map.
If you want to save the cities layer as a GeoPackage or shapefile, so that you have a permanent, mappable cities layer, then you can do this by right-clicking the layer and then Export > Save Features As... and then choosing the Format, then where to save it via the Browse [...] button, giving it a File name and then hitting Save and then OK to finish.

**N.B.** If you save to a new layer when you have it filtered, only the filtered features will be in the new layer. You can do this with any kind of layer and it's useful if (e.g.) you want to save a copy of a layer, or save it in a different file format – like if you want to save a shapefile as a GeoPackage.

Here's my screen at this point. Let me know if you need help.



Notes

We've just symbolised the countries using a simple colour. Now let's symbolise the countries layer in different ways. There are a couple of ways we can do it, but the main ways we'd do it are as follows. *Read the two bullet points first* and then try it yourself.

- Categorized – this is where you style a layer using some kind of category data in the Attribute Table. We have quite a few category fields in our countries layer – have a look at the Attribute Table and you'll see them (e.g. REGION_WB is the World Bank region for each country). Categories are usually words, but of course they could also be numbers (e.g. to represent land use classes).

- Graduated – this is where you style a layer using some kind of numerical value – e.g. like GDP per capita or population density, and then use a colour scale to show the graduation between high and low values. This is known as a choropleth map. The 'choro' bit relates to area or region – from the Greek χῶρος – and the 'pleth' bit relates to quantity, as in 'plethora'.

These styling options can be accessed via the Layer Styling panel in QGIS (also via Layer > Layer Properties… > Symbology).

- Using your spare world_countries layer have a go at styling the layer using Categorized and then Graduated methods. Make sure the layer is visible in the map view – i.e. untick the other one if it's on top. I'll do a live styling demo soon.

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Notes

You can see in my example to the right how I've chosen to symbolise my 1_world_countries layer using a Categorized method and using the REGION_WB Value from the Attribute Table.

This colours all world countries by their World Bank Region.

The only thing you REALLY need to do here is remember to hit Classify once you've chosen your symbology scheme. Otherwise nothing will happen!

When you change to a new classification, QGIS will ask if you want to delete the previous one – you can click Yes if this happens.



Notes
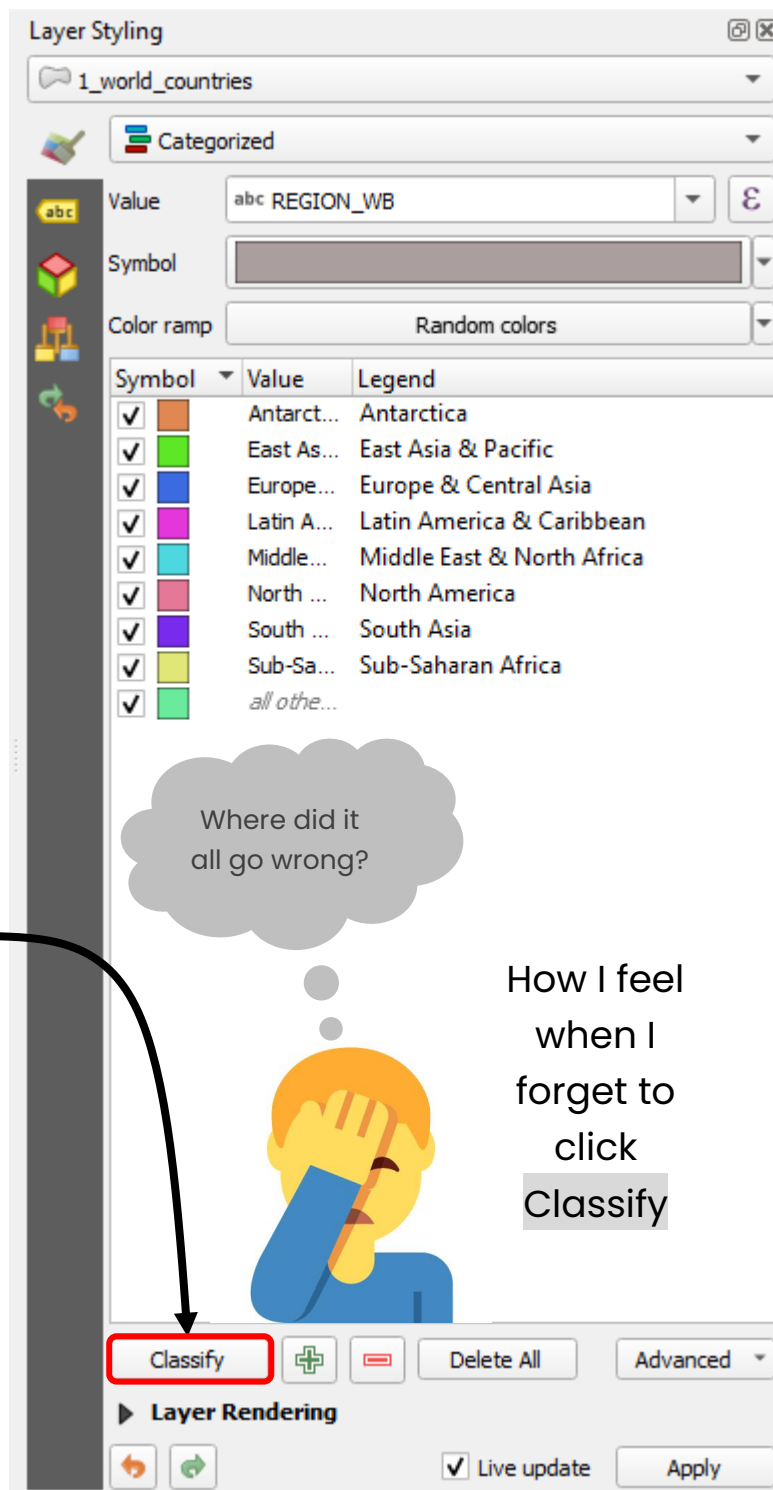
**Top tip – show how many features are in each category/class**
When you've symbolised data into different categories, it's often important to be able to tell how many features are in each category or numerical class. Right-click a layer name in the Layers panel on the left, and then tick the Show Feature Count box to see how this works.

Now it's time to take a bit more of an in-depth look at Symbology, using the layers we have on the map. You can follow along as I go and ask any questions as they arise.

**Follow along demo time**
I'll do a follow along live demo of Symbology now.

Whether I do it via the Layer Styling panel, Layer > Layer Properties... or just access the Layer Properties by double-clicking on the layer name (I find this way quickest and easiest), it always takes me to the same place. Or click this icon! 🖌️ Let's look at the following ways of symbolising a layer.

**Categorized**
Let's try to categorise using some of the different fields in our countries dataset, including CONTINENT, MAPCOLOR13, SUBREGION, and so on. So long as we keep hitting Classify, we're going to be successful.

**Classified**
We can also create different kinds of choropleth map using the data in the Attribute Table. We can map totals here, but normally we shouldn't so we'll look at how to standardise by population. Classification Mode? That's things like Equal Count (Quantile), Natural Breaks, etc. We'll look at this.

**Using expressions**
We can do this using the Categorized or Classified methods – using calculations or by extracting values from strings. Be amazed!
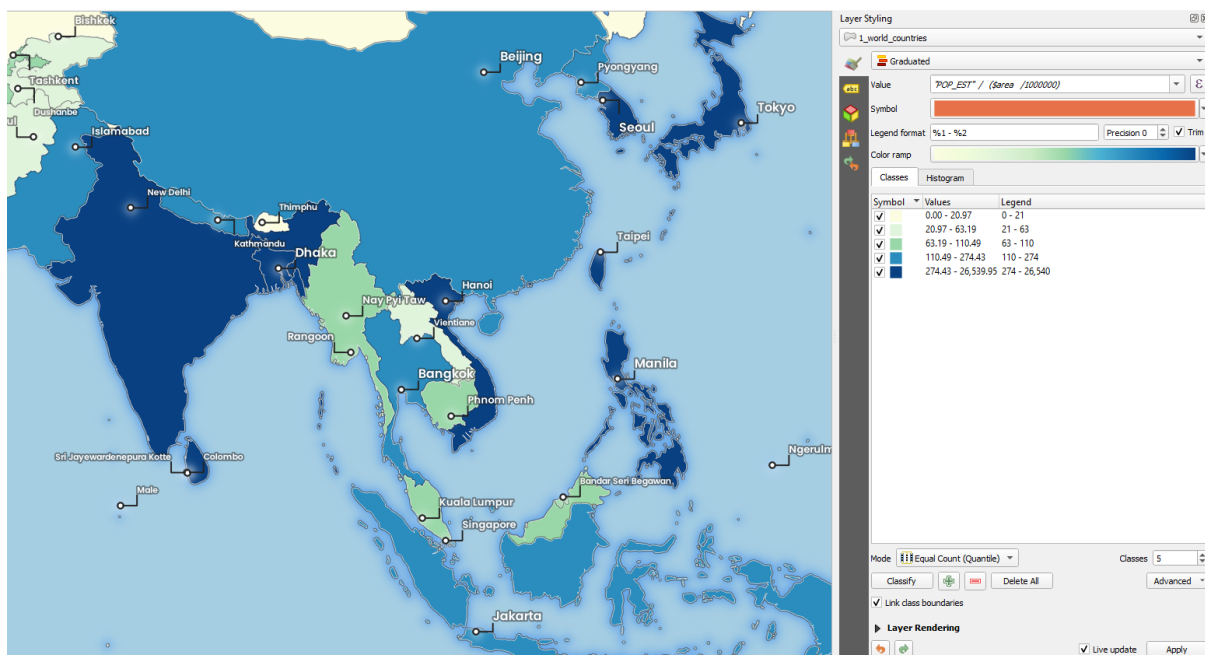
Notes

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**Time to save your work again**

Save your work now – e.g. as qgis_intro_p20.

I won't add in this save box again because I'm sure you can remember yourself but I will add in the save icon occasionally as a little reminder.

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Here's a screenshot of what I have at this point – for reference.



Okay, so we're making maps now. That's great. Want to know how to save a style *within* a layer, or as default? Just ask me.

But of course any GIS work is about much more than maps – or at least it should be. It's also about querying data, doing spatial analysis, and mapping new things. We'll look at these next, beginning with how to join data from a spreadsheet to an existing map layer.

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Notes

## 4. Joining data – map anything!

So far we've done some basic things, including:

- Exploring the QGIS interface;
- Adding different kinds of data to QGIS;
- Styling layers in different ways.

Now we'll look at how to join data in QGIS. Here's an example of how this typically works (after this, you'll have a go yourself).

1. You have some map data in QGIS (e.g. a shapefile) of all the countries in the world – like we do right now. In the Attribute Table of this layer you have a column with a three letter code for each country (e.g. the ADM0_A3 column).

2. You decide you want to explore, compare and map country populations, so you find a spreadsheet online with the data (i.e. like our dataset 4 xlsx file). The spreadsheet also has a three letter code for each country and these codes appear to match the country codes you have in your shapefile, so you're all set.

3. You then join the spreadsheet data to your map layer (it could be a shapefile. GeoPackage or any other geospatial file format) and then once the join is done you can then map the previously unmappable spreadsheet data.

Let's have a go at this now.

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Notes

- You should already have the 4_world_bank_population_data_1960-2019 file in your QGIS Layers panel, but if not, add it now. Open the Attribute Table 🗐 and then you'll see that the file has a Country Name column, a Country Code column, and then population data for each year from 1960 to 2019.

- If you sort the columns by clicking on (e.g.) Y1960 you'll see that the file contains data for the world, and different world regions – this isn't a problem though, because QGIS will only join the data where there is a matching country code in both datasets. You can close the Attribute Table now.

- Double-click the 2_world_countries layer and then go to the ◀ Joins area to the left of the Layer Properties window.

- Start the join by clicking the little green plus ⊞ to the bottom left of the Layer Properties window.

- You will then see the Add Vector Join options. This can be confusing at first but all you are doing is telling QGIS which data you want to join to the existing map layer, which columns (aka 'fields') your matching country codes are in – plus some other options.

- Take a look at the next page and make your Add Vector Join settings look like mine. When they do, click OK, then OK.

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Notes
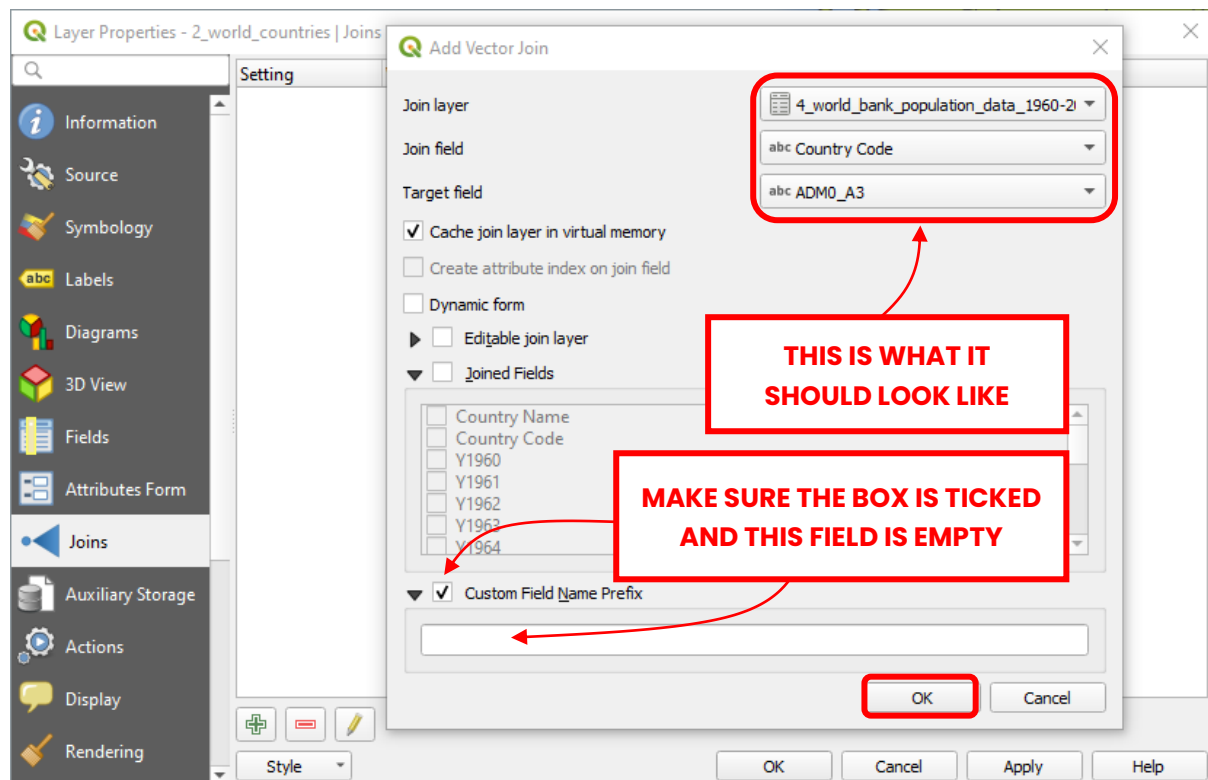
- Once you've clicked OK to create the join and then OK to exit Layer Properties the join will be complete – but how do you know?

- You can see the join has been successful by opening the Attribute Table of the layer you just joined the spreadsheet data to (in my case it was 2_world_countries) and then scrolling right to see the newly appended data.

- This is what I always do once I've performed a join – just to check it. Have a look yourself now and you should see all the country population data. **Follow the instructions in the box on the next page to export the joined layer.**

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Notes

> **Remember this**
> When you perform a join like this, it's **not** a permanent thing.
>
> Think of it more like a temporary connection between files. If we want to permanently save the joined data, we can export it as a new layer in QGIS. This is done via a right-click from the layer we joined the data to (i.e. right-click the geographic layer you joined the data **to**, not the one it came **from**.
>
> Then it's a case of Export > Save Features As… and save the new layer in your preferred format, with a meaningful name. Note that when you are exporting to a new layer, the Save Vector Layer as… options in QGIS allow you to select which fields to include in the export – that is, you get the choice of which Attribute Table columns to include in the new layer – very useful if you only want a few of them.

- I saved my new joined layer as 2_world_countries_with_pop_data.shp and it then added to the map as a new layer. Make sure you've done this too, though don't worry if your file name or format is different.

If you ever need to edit a Join, you can do this by going back to Layer Properties > Joins and clicking the little pencil icon.

- Sort the Y2019 column of your newly joined layer by clicking on the column header. Lots of NULL values? Have a look at which countries or areas these are. Ask me about it if you have any questions.

- Let's remove Antarctica. Right-click the new layer, then Filter… then use this query: NOT "SOVEREIGNT" = 'Antarctica'

Notes

## 5. Exploring data (including base maps)

The idea in the early part of this workbook is to get you up to speed with QGIS, as well as just becoming familiar with the interface – how it looks, where to find stuff. That's why it was more step-by-step. As we go on, we'll do less of that, starting from now, but if you need me to demo something, let me know.

It's often very useful when doing any mapping to be able to add a high resolution base map (e.g. Google Maps, Bing Maps, or OpenStreetMap). Let's add one of these in right now.

- Turn off (untick ☐) all your map layers apart from the 3_world_cities layer ☑ . In the Browser, expand (via little black triangle ▾) XYZ Tiles, then double-click OpenStreetMap to add it to the map.

- Change the projection to WGS 84 / Pseudo-Mercator (remember, via the little EPSG button in the bottom right). This is the projection you'll need to use to ensure any XYZ Tiles maps are 100% crisp and not slightly fuzzy-looking.

- Zoom ⊕ and Pan ✋ and explore the map a little – for example, check if the city points you imported earlier via the csv file are in the right place on the map.

- Change the Query on the world cities layer (via ▽) to "country" = 'Belgium' AND "population" > 100000 and have a closer look. You can use 🔎 to quickly zoom in to layers.

Notes

- Change your OpenStreetMap base layer to 50% Transparency and in Symbology to Grayscale > By lightness.

Here's what my map currently looks like – below – based on the following query: "country" = 'Australia' AND "population" > 150000



The base map here provides some additional context, though isn't strictly necessary – but it can often be really useful.

---

Notes

## 6. Querying data – start asking questions

The idea behind this part of the workbook is that we start asking questions of our data and using queries to find the answers.

Here's an example: *The World's Cities in 2018* report from the United Nations identified Tokyo as the world's largest urban agglomeration (they call it 'city' but really it's the wider urban area), with a population of 37,468,000. We want to see how many countries in the world have a lower population than this, and then map it.

- Run this Filter… **on your new country + population layer**: "Y2018" < 37468000 AND NOT "SOVEREIGNT" = 'Antarctica' (note that the 'AND NOT…' bit just keeps Antarctica turned off). See below for my results (I've turned the projection back to World_Robinson here – you can do this too).



Tokyo metro area has a lot of people in it!

Notes

Note that in QGIS you can use this same query syntax to select features as well. For example, if you wanted to select all countries with a lower population than 'Tokyo' and then Export the selected countries to a new layer. The query is the same, but you'd do it via the Select Features by Expression… button (as shown below).
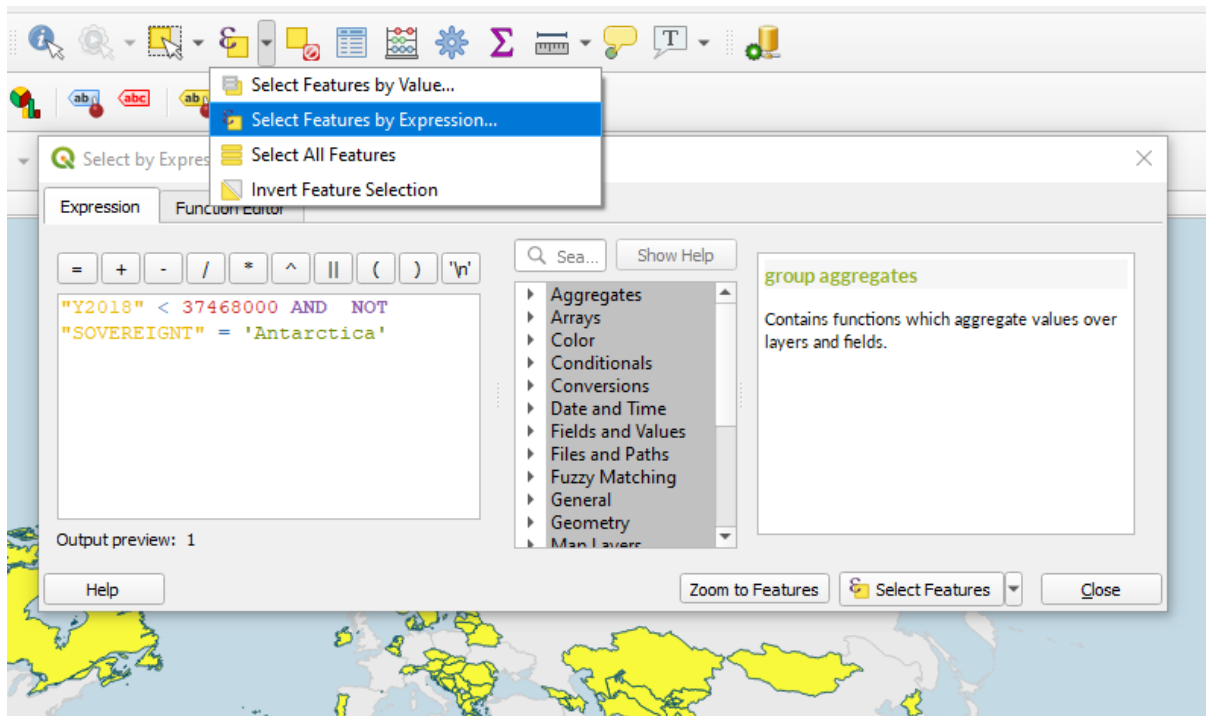


How do you know how many countries are included in a Filter or Select operation? You'll always see this information at the top of an Attribute Table's window, and for a Filter you can see the number of features via a right-click and Show Feature Count.

On the next page I've set you a series of questions that can be answered using the map layers we have. Can answer them all?

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Notes

**Q:** In the 3_world_cities layer, how many cities have a population of more than 20 million?

**A:**

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**Q:** Of the above cities, how many are capitals? (hint: "population" > 20000000 AND "capital" = 'primary')

**A:**

---

**Q:** How many countries have a population of more than 100 million?

**A:**

---

**Q:** How many 1. High income: OECD countries have a population of more than 100 million? (hint: you might use AND twice here)

**A:**

---

**Q:** How many countries start with A, B or C? (hint: undo previous Filters, then do this one via Select Features by Expression... and then with this text left("GEOUNIT",1) IN ('A','B','C')).

**A:**

---

We know how to do queries - let's look at spatial analysis next.

Notes

## 7. Spatial analysis: beyond maps

QGIS can display maps, as you've seen. You have also seen how you can query the data behind those maps.

Let's take a look at how to do some simple spatial analysis tasks.

- First make sure nothing is selected on your map (Deselect Features from All Layers 🔲) – it's also a good idea to save your project now, adding the page number to the project file name like before. 💾

- Now make sure a countries layer is visible, and unfiltered (it's fine if Antarctica is still turned off with a filter though).

- Now, with your countries layer selected in the Layers panel on the left, use the Select Feature(s) 🔲 tool to select the Democratic Republic of the Congo – just click on it.

- Now go to Vector > Research Tools > Select by Location… and, using ☑ **Selected features only**, Run the query, just like in the screenshot below (you may be using a different countries layer, in which case that's fine).

- Keep the Select by Location window open, and keep reading on the next page.

Notes
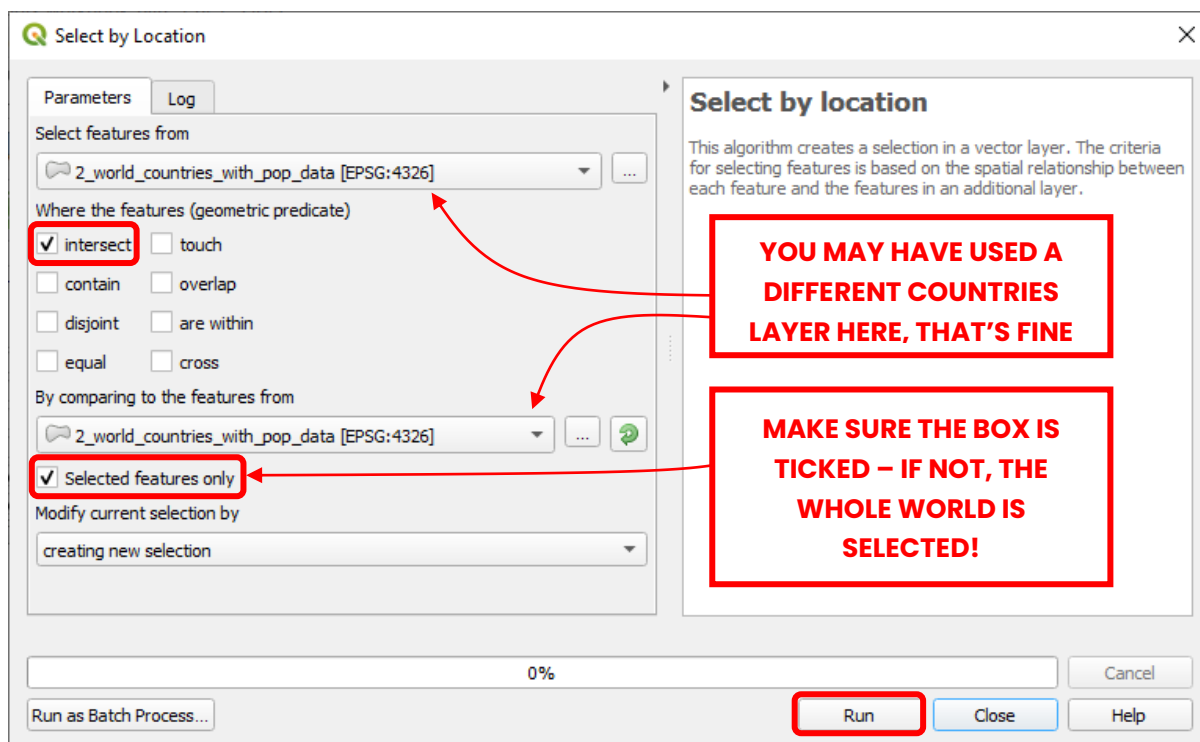
- You should now see that all countries that border the Democratic Republic of the Congo are selected. Now keep pressing Run and QGIS will select the countries that border those, and so on and so on. Then Close the Select by Location window and unselect 🔳 all features.

- Now I want you to select Bolivia 🔲 from your countries layer, turn on your 3_world_cities layer, plus a countries layer, and go back into Vector > Research Tools > Select by Location… and then select all cities that are within the selected features of the countries layer. This is a simple point-in-polygon GIS operation where QGIS is able to select features from one layer, based on another.

Notes

Here's what the Bolivia query above looks like on my machine.
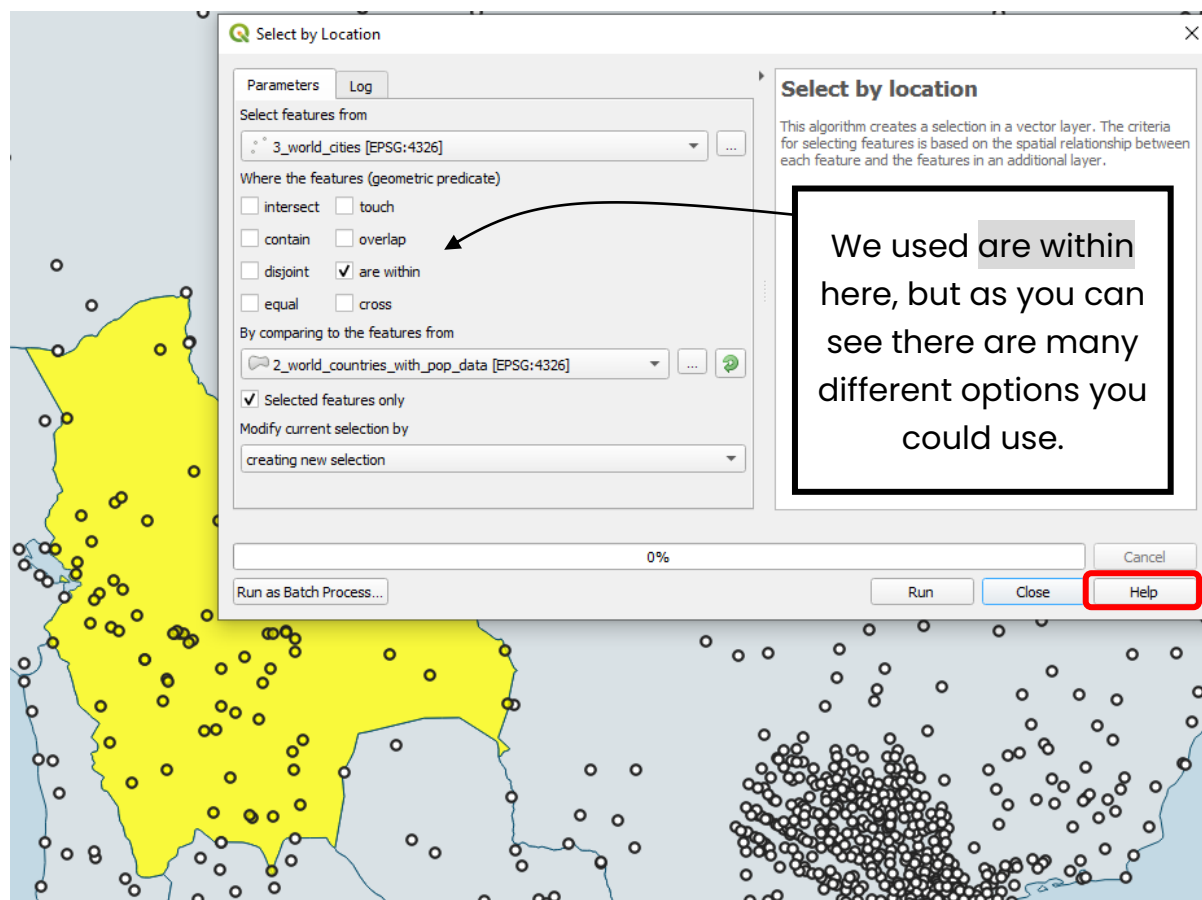


- If your Select by Location query didn't work first time, try it again using the options above. It should select 78 places.

- I also want you to click on the Help button to see what happens – this is *so* useful because it takes you directly to the QGIS help pages. You can close Select by Location now.

That's the end of our little spatial analysis mini adventure for now – now it's time to make some pretty maps!

Notes

## 8. Using the Print Layout to make a map

We're going to spend some time now looking at how to create a nice map in the Print Layout. This is the area of QGIS where you design, edit and export high quality maps. The main map viewing window is generally where you explore, analyse and investigate data – although it is also possible to export high quality, production-ready maps directly from the main map view as well (though with fewer features).

Here's what we're going to create (below) – if you want to do some variation of this, that's fine with me.



The World's Biggest Megacities in 2030

Country income group
- High income
- Upper middle income
- Lower middle income
- Low income

The United Nations predict that Delhi will overtake Tokyo as the world's largest city by 2030. Their definition of 'city' refers to the wider urban agglomeration rather than the city proper in each case. As of 2018, the Tokyo urban agglomeration had a population of more than 37 million people.

Source: The World's Cities in 2018, United Nations

Made with QGIS

https://automaticknowledge.org/training/data/styles – this is where you will find the layer style files (qml) and this image. You can load styles via Layer Properties then Style > Load Style.

Notes

I'll get you started with the Print Layout tools, do a bit of a follow along, and then you can take it from there. But first, do this:

- Open a new Print Layout in QGIS– you can do this via the New Print Layout button 🗒️, via Project > New Print Layout... or via CTRL+P (on Windows) and ⌘+P (Mac).

- Give the new Print Layout a name, when prompted – I called mine Megacities.

You'll then see something that looks like a blank piece of white paper on a grey background – as below. Have a close look at it, then go to the next page where we'll work through it.



Zoom to full page

Refresh page

Tools to position and align Items.

Select and move an item

Move map *within* frame

The single most important button – this adds your map to the page.

Use these tools to add a legend, text, image, shapes, scale bar and north arrow.

To set the Page Properties, including size and background colour, right-click and select Page Properties... and then edit them in Item Properties.

All Items will appear here – use the tick box to show/hide.

This is the Item Properties tab – everything you add to the page is an Item and can be edited here. You'll use this a lot.

Notes

**Follow along demo time**
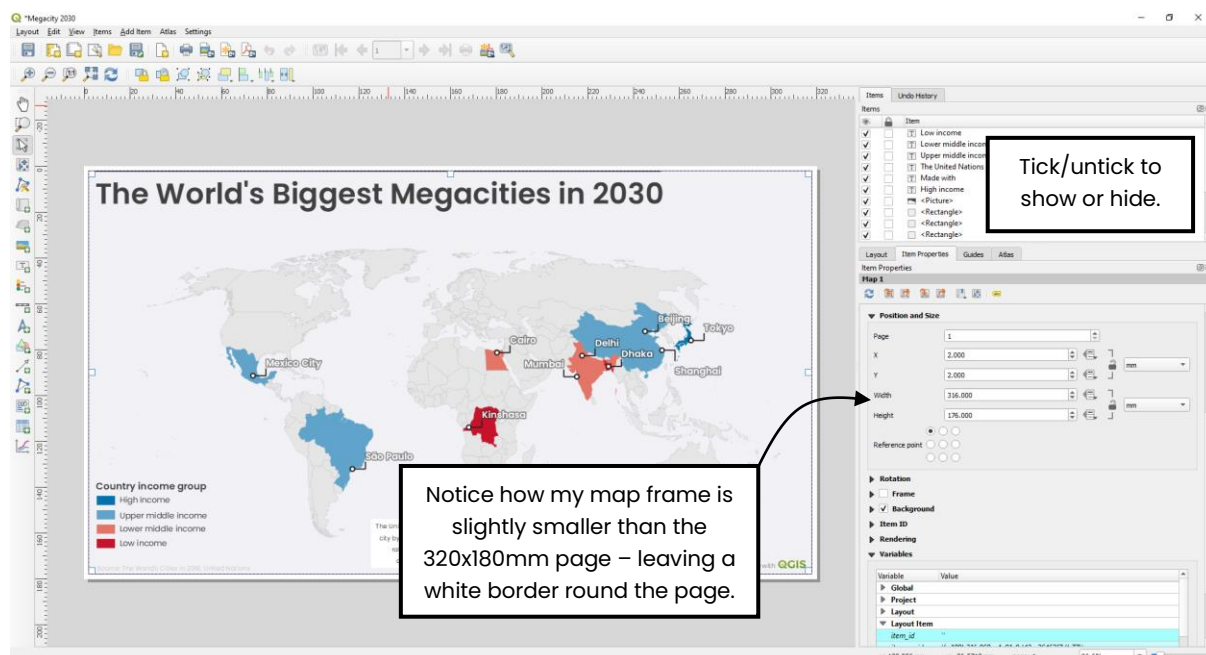
Okay, time to get the layout as we want it, so try to copy me.

Here are the steps I'll go through so you can follow.

- I normally set the page size to 320.00mm x 180.00mm because this is the correct aspect ratio for full screen viewing (i.e. 16:9). But you can choose pre-set page sizes, including A4 and US Letter sizes.
- Next, I usually add a map – with a simple click and drag. I will often re-size this to match the page size, but sometimes I leave a white border.
- Note that when you move Items around a Print Layout they 'snap' to centre, middle and edges, as well as each other. This is very helpful.
- Then I'll edit the map scale via Item Properties on the right.
- Then I'll position the map inside the frame using Move item content.
- Then I'll add text (title, source, annotations), and re-position/re-size.
- I often go back to the map data to tweak the symbology as I'm doing this, if I'm not happy with anything.
- Sometimes I use the built-in Legend tool, sometimes I add shapes manually, then copy them to create my own legend.
- I usually only add a north arrow and scale bar if it's essential.
- I tend to prefer a subtle off-white colour for the background, with a white border to help focus the eye on the main map frame.
- I use #222222 for dark text rather than #000000 (100% black).
- If I add an image, I always try to use a svg, they tend to look crisper.
- A subtle title guide line (as in the example above) is a nice touch.
- I try to achieve visual balance, and object alignment.
- When I'm happy with it, I go to Layout > Export as image… and then save a 300dpi png. Then I inspect the exported map closely and go back and fix things I don't like – often many times.
- I make sure I save my project here as I go, just in case disaster strikes.
- I often add some kind of explanatory text and/or annotation to the map, and make the title as clear as possible.

Notes

Here's a screenshot from my Print Layout, the same one that generated the image I showed you previously.



Tick/untick to show or hide.

The World's Biggest Megacities in 2030

Country income group
High income
Upper middle income
Lower middle income
Low income

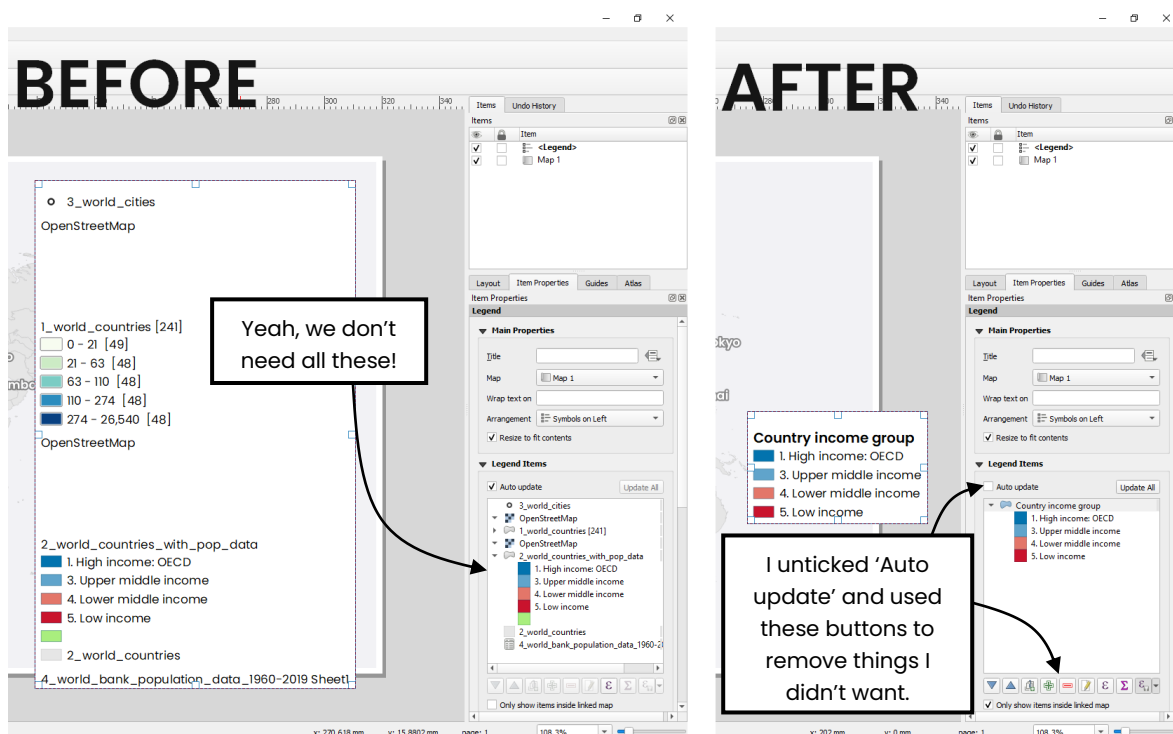Notice how my map frame is slightly smaller than the 320x180mm page – leaving a white border round the page.

If you're used to other GIS software, or none, then the QGIS Print Layout can be baffling, frustrating or both. I felt the same way when I first started using it, but once you get over the initial '*what* the **#!@*&%**!?' feeling, you have so much flexibility and freedom to create great maps and graphical layouts.

If you remember this basic approach, though, you should be ok:

**Add an item (map, shape, text box, etc.) to the Print Layout. Edit its properties in the Item Properties tab. Refresh Print Layout if you change any of the map content. Navigate map *within* layout using this button . Save project. Save map via Layout > Export as image...**

Notes

The best way to become proficient with the Print Layout is to spend time experimenting with it, and using it for real.

The only other thing to add here is that when you add a Legend, by default *all* the layers you have in your map will be in it. See the little 'BEFORE' and 'AFTER' comparison below where I have shown the default on the left, and the edited Legend on the right.



**BEFORE**

Yeah, we don't need all these!

**AFTER**

I unticked 'Auto update' and used these buttons to remove things I didn't want.

---

**Top tip**

This 🔲 button is how you select/move individual Print Layout items.

Use the little zoom tool in the bottom right of the Print Layout window to inspect in detail how your final export will look. `360.0%`

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Notes

## 9. Exporting maps (two ways)

You can export maps from QGIS in two main ways.

1. Export a map from a Print Layout, as we have seen above. You can export in lots of different formats, via Layout › Export as Image… or by clicking one of these three buttons (the first is for image formats like png, the next is for svg and the final one is for pdf exports).

2. You can also export maps directly from the main map view in QGIS, using Project › Import/Export › Export map to Image… - this is less flexible but it can also be really useful. Also, once you're in the Export map to Image… options, you can choose to Copy to Clipboard and then paste your map into another application (e.g. into a slide show, or email).

In general, I'd say always use the first option above if you want to create the highest quality maps, but if you're just looking to export a map view to provide a general overview, or to show someone what you're working on, the second option is very useful. You should be able to open the svg in a web browser.

- From the Print Layout you currently have open, try to export your map once each as a png (300dpi), jpg (300dpi), pdf and svg – if there's time for this. Once you've done it, compare them – e.g. image quality, details and so on. I always recommend a 300dpi png when exporting maps.

---

Notes

This kind of experimental exporting and comparing of formats is not something most people think about doing, but it can be very helpful. In general a 300dpi png is preferable over a 300dpi jpg because the png is a 'lossless' file format and what you see in your Print Layout is what you'll get in the final file, quality-wise.
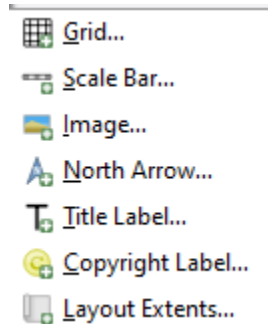
With jpg, you will often notice a fuzziness, particularly with red shades, because it is a 'lossy' file format.

- Now go back to your main QGIS map view, and at this point I'd recommend saving your project again – as before, with the current page number added to the project file name.

- Before we go to Project > Import/Export > Export map to Image... I want you instead to do the following: go to View > Decorations and then you'll see the following options, below.

- You can add a variety of different Decorations, as QGIS calls them. When you go to export images in this way, these Decorations will be included in your image file, unless you untick the Draw Annotations box in the Save Map as Image window.

  | Grid... |
  | Scale Bar... |
  | Image... |
  | North Arrow... |
  | Title Label... |
  | Copyright Label... |
  | Layout Extents... |

  You'll find these options simple enough to use, so see if you can replicate my screenshot below, with Title Label... Copyright Label... (used for the 'Source' text) and Image...

Notes
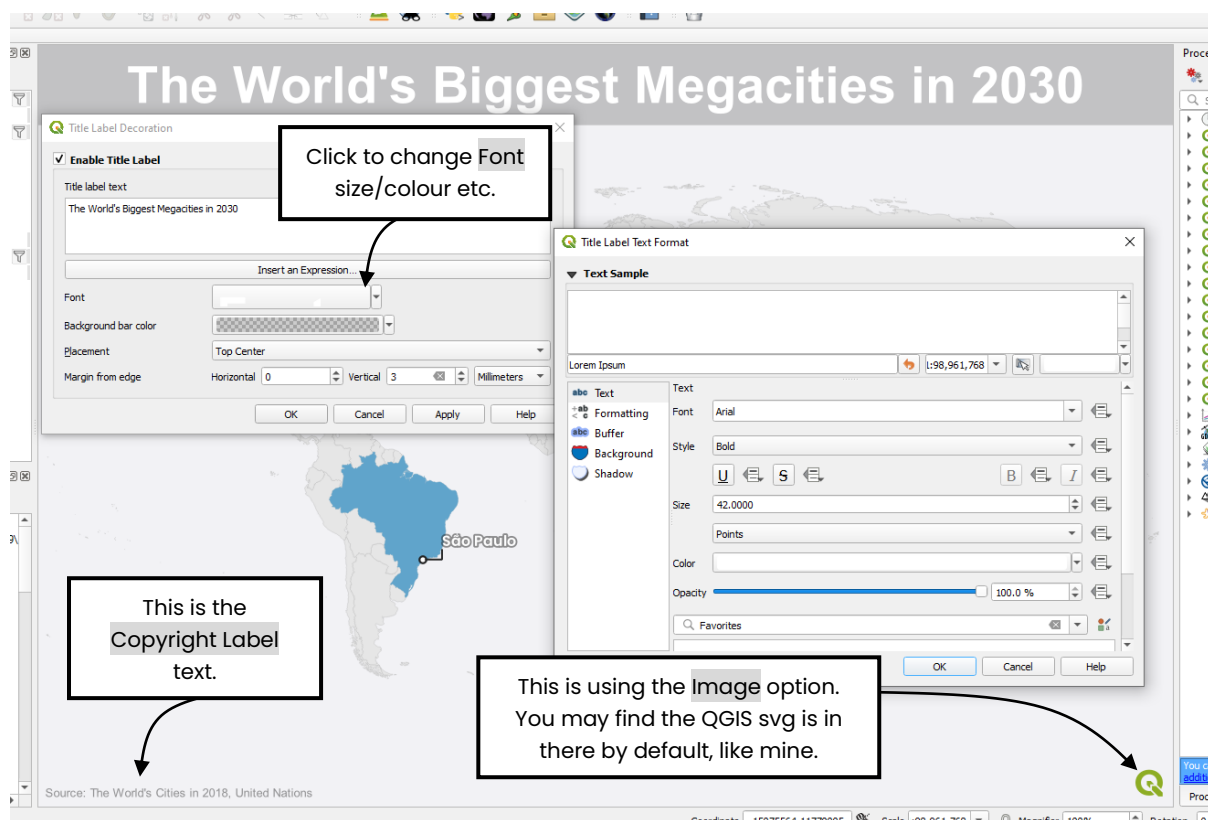
- Once you're happy with the way your map looks, go ahead and export it as a 300dpi png or as a pdf.

- If you've come this far you've done well! Save your project once again, take a deep breath, and then go to the next page.

**Baffled?**
Are you baffled, mildly confused, just wondering about something?
If so, that's 100% to be expected because there is a lot of material in here – so long as you have mastered the fundamentals and know your way round QGIS that is great. But feel free to ask me anything now, or later.

Notes

## 10. Putting it into practice

If you've reached this point before the scheduled end of the training session, that's great – you can now continue and perhaps take things a step further (but feel free to chill, go off in your own direction, or just ask me anything). With this in mind, here are some suggestions for ways you can put all your QGIS skills into practice, now or in the future.

- You could do some more filtering and/or labelling on different layers – e.g. using the explanatory text in the 3_world_cities_megacity_2030.qml layer I provided in the data/styles folder you could try and experiment further.

- You could do a map of all world countries with a lower population than Tokyo's metropolitan area – you may remember I shared an example of this earlier on.

- You could do a map showing countries with the highest population growth over a certain time period – this could be done by as a Graduated symbol with ("Y2019" - "Y1960" ) / "Y1960" * 100 used in the Value field.

- I mean, you could do just about anything, including a Categorized style, mapping all countries that start with an I – using this in the Value field: left( "GEOUNIT" ,1) = 'I'.

If you have any questions after this session, or you just can't figure something out, feel free to get in touch.

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Notes

## 11. Credits

**QGIS** - QGIS is a user friendly Open Source Geographic Information System (GIS) licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo).
https://www.qgis.org/en/site/about/index.html

**Natural Earth** – 'no permission is needed to use Natural Earth data'. All versions of Natural Earth raster + vector map data found on this website are in the public domain.
https://www.naturalearthdata.com/about/terms-of-use/

**SimpleMaps** – World Cities Database (Basic), used under the Creative Commons Attribution 4.0 licence.
https://simplemaps.com/data/world-cities

**World Bank** – Population data, used under the Creative Commons Attribution 4.0 licence.

https://data.worldbank.org/indicator/SP.POP.TOTL

**Emojis** are from Twemoji, at twemoji.twitter.com, licenced under the CC-BY 4.0 licence.
https://twemoji.twitter.com/

**Poppins Font** - Designed by Indian Type Foundry, Jonny Pinhorn, licenced under the Open Font Licence.
https://scripts.sil.org/cms/scripts/page.php?site_id=nrsi&id=OFL

Notes

## 12. Useful links

**Natural Earth** – the best source for easy-to-use global map data, e.g. countries, places, states, roads, coastlines and much more.
https://www.naturalearthdata.com

**simplemaps** – world cities csv files, with lat/long coordinates. This is a great source for place name data.
https://simplemaps.com/data/world-cities

**Sentinel-2 cloudless** – for adding satellite imagery to QGIS. Right-click WMS/WMTS in the QGIS browser panel, then click New Connection... add Sentinel-2 cloudless to the Name and the second url below to the URL field.
https://s2maps.eu/
https://tiles.maps.eox.at/wms?service=wms&request=getcapabilities

**OS OpenData Downloads (Ordnance Survey)** – a huge amount of free, open geospatial data are now available from Ordnance Survey via their Open Data Hub. The data covers Great Britain and no registration is required.
https://osdatahub.os.uk/downloads/open

**ONS Geography Portal (UK)** – see the Boundaries section of this website for a wide range of UK boundary data. This site includes data for the whole of the UK, whereas Ordnance Survey data only covers Great Britain. A great resource.
https://geoportal.statistics.gov.uk/

**QGIS Documentation** – the official help docs from the people who make QGIS.
https://www.qgis.org/en/docs/index.html

Notes

## Back page cheat sheet

These are things I use myself – to make things work faster, better, smoother.

- CTRL+Tab turns panels on/off so the map area is full screen width.
- Select some features, Edit > Copy Features then Edit > Paste Features As a new temporary layer (called a 'scratch' layer) or a new vector layer.
- F11 for full screen mode, F1 for QGIS User Guide, F6 to open Attribute table (on Windows).
- CTRL+Shift+Tab for full screen map mode (on Windows). Same again to undo.
- Change projection for project (it doesn't alter any data) via EPSG button, bottom right.
- Black is too harsh, try #222222 / RGB 34, 34, 34 instead. Go beyond default colours!
- Where is your layer stored? Double-click a layer, go to Information and see Path.
- Turn on the thousand separator (1,000 vs 1000) – Settings > Options > General, tick box.
- Want to save the position of your map? Use View > New Spatial Bookmark.
- Print Layout looking fuzzy? Just hit refresh and that will fix it.
- Print Layout page not zooming to full extent? Re-size your page, then reset to original.
- Save your most commonly used data source paths as Favorites in the Browser.
- When styling layers, you don't have to use only the columns you already have – e.g. you can style based on calculations or even by extracting portions of text.
- Hey, my lovely XYZ base map looks a bit fuzzy! Set projection to EPSG:3857.
- Hey, my joined layer has weird column header names! Go back into Joins, and edit the join so that the Custom Field Name Prefix is ticked and the box is blank.
- How do you do those glowing lines/polygons? That's via Blending mode in Symbology.
- Help! My side panel things have disappeared. Go to View > Panels.
- Use Inverted polygons with a filter and a satellite base layer to create nice area maps – make layer white/black and use about 75% Opacity.
- Go to Processing > History to view or re-run your recent geoprocessing tasks.
- A general carto tip: try to make your map as simple as possible, remove any junk.
- Type world into the Coordinate box if you want a world countries layer to use.
- Use a 16:9 aspect ratio if your maps are mainly for screens (e.g. 320mm x 180mm).
- Map a list of x and y coordinates quickly via Delimited Text in Data Source Manager.
- Drag and drop files from your file browser directly into QGIS (e.g. shp, gpkg etc).
- You can add layers via the WMS/WMTS option in Browser. Just Google it.
- Want to save/re-use a map style for a layer? Layer Properties > Style > Save Style…
- If you give the qml file the same name as a layer file and put it in the same folder as the file then when you add it to QGIS that style will be applied by default.
- Learn about Draw effects! Use them to add a glow or a shadow to features.
- View > Preview Mode to see your map in colour-blind safe modes or greyscale.
- Best Plugins? MMQGIS, SRTM Downloader, Build Globe View, Qgis2threejs, qgis2web.
- Add base maps via XYZ Tiles in Browser panel. OpenStreetMap is there by default.

Notes