

2019

Evaluating the Use of GIS Software as a Modelling Tool for Environmental Analysis

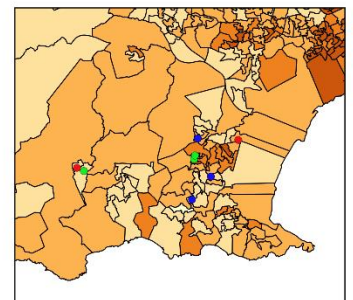
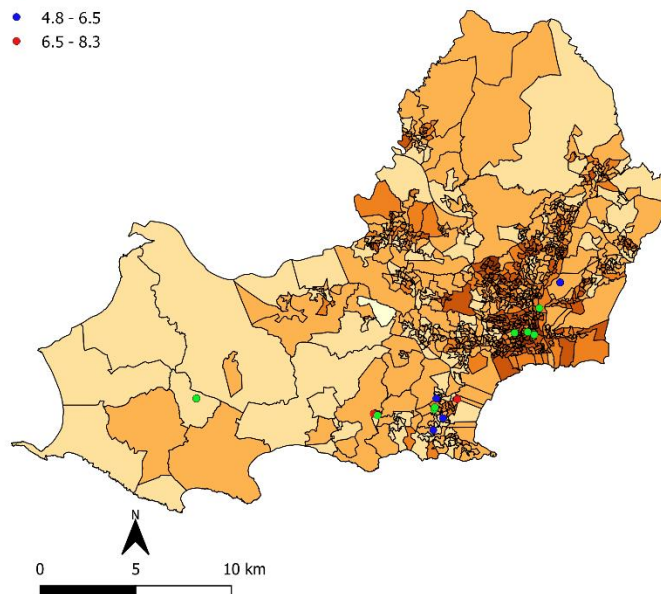
Household Ecological Footprint

Reap_Data_Shapefile_EF

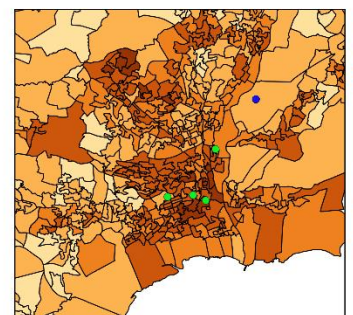
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Introduction

Geographical Information Systems (GIS) are an important tool for scientists and policy makers for a variety of purposes, from assessing the viability of a proposed scheme to investigating causation of a phenomena at any given location. They are used widely by Councils, governments, independent advisory bodies and charities. (Holland & Gardiner, 2010; QGIS, 2019)

An important benefit of using GIS software is that they allow the user to spatially analyse data in relation to topographical features, social factors and personal observations. Their applications are wide-reaching and holistic, often resulting in the ability to present data in the form of a map which other systems may not allow. In this sense, GIS is reliant on visualisation systems whilst the reverse is not necessarily canon. (Deakin, 2009)

Quantum GIS (QGIS) is a Free Open Source Software (FOSS) used by many conservation and government organisations, such as Welsh Water, DEFRA (Ashelford, 2017) and UK Government (Crone, 2017). Conservation, in particular, has benefitted from the prevalence of GIS software's (GIS Lounge, 2014; Dessau & Sutton, 2011). (OSGeo, 2019)

The revolution of data availability and accessibility brought about by the development of the internet has facilitated the creation of much open-access data to be enjoyed by policy makers and scientists alike. This data can then be used to calculate scores in a number of areas, for example of how deprived an area is relative to other areas. One such calculation is the Townsend Deprivation Index (Norman, 2001). (UK Data Service, 2019)

A common belief among scientists is that "if it's not measurable, it's not manageable". As poverty is more complex than economic class or the level of disposable income an individual has, the Townsend Deprivation Index relies on a whole host of other indicators, based on the human rights framework (Townsend Centre for International Poverty Research, 2019; The Universal Declaration of Human Rights, 1948).

This study will use QGIS to investigate the characteristics of data collected on the ecological footprint of residents living in the SA1 (Swansea City Centre) and SA3 (Mumbles) areas of Swansea, South Wales. Correlations between this data and the Townsend Deprivation Index will be discussed. A case study will be presented, describing and evaluating the use of QGIS for conducting the described task, and suggestions for developments made.

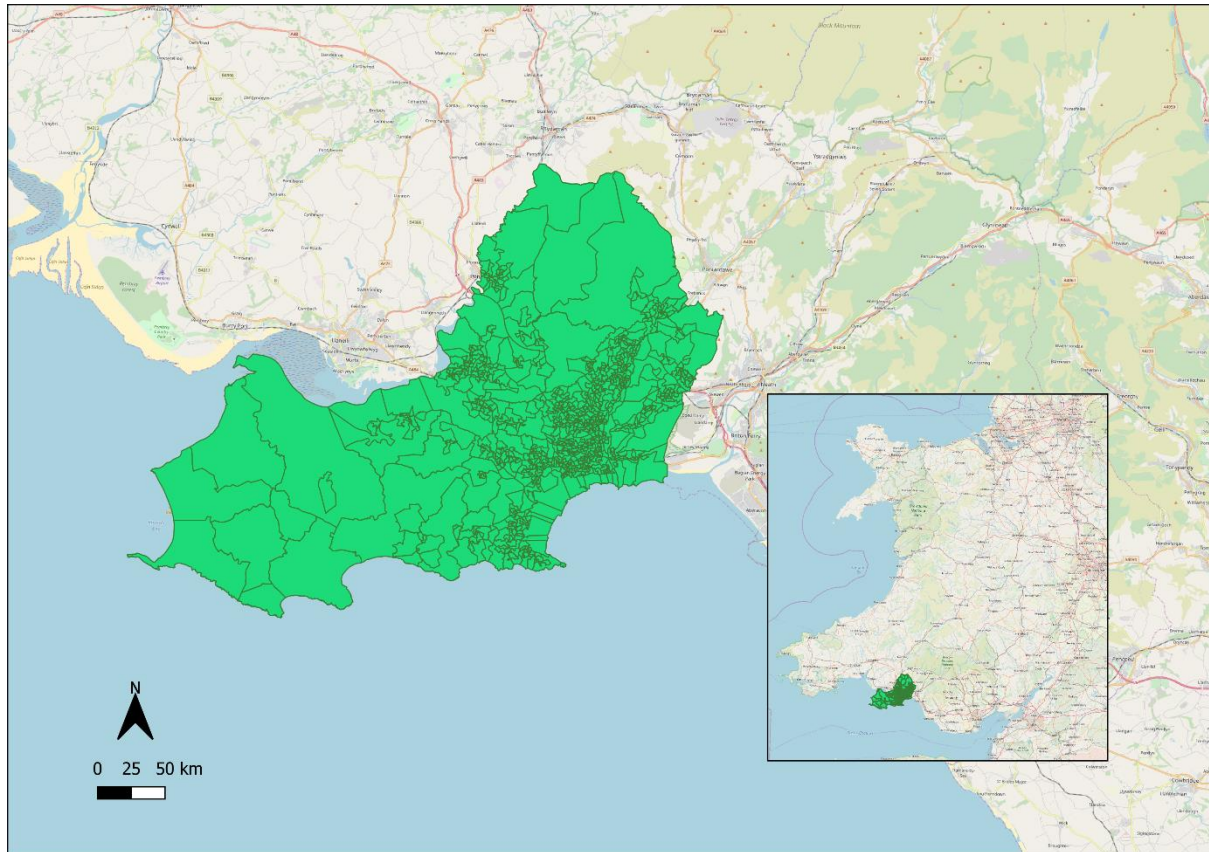


Figure 1: Map of study area in relation to Wales.

Methodology

Data Sources

The data used in this report has come from a number of sources. Firstly, the Census data was retrieved from UK Data Service (UK Data Service, 2019), the Townsend Index was then calculated from this. Further data was collected by students at the University of Wales, Trinity St. David using a method adapted after Davies and Denner (2012) and Alun (2015). Questionnaires were distributed and completed by residents of the SA1 and SA3 areas of Swansea, South Wales. The questionnaires were returned in physical format and inputted to REAP Petite, results were then analysed using Excel. The questionnaire was divided into eight sections: demographic information, housing, food, travel, shopping, activities, waste and water use. (Wilkinson, 2019)

Calculating the Townsend Index

The Townsend index was calculated using data from the UK Data Service, specific data sets are listed in the table below.

Figure 2: Table of data sets used for calculating the Townsend Index.

Variable ID	Variable Description
Overcrowding:	
F2376	All households
F2380 + F2381	Households with an occupancy rating of -1 or less
Unemployed:	

F256	People aged 16-74: Economically active: Employees Part-time
F260	People aged 16-74: Economically active: Employees Full-time
F557 + F559	People aged 16-74: Economically active: Self - employed
F248	People aged 16-74: Economically active: Unemployed
F267	People aged 16-74: Economically active: Full-time student
Owner Occupancy:	
F2347	All households
F2351	Households: Owner occupied: Owns outright
F2353	Households: Owner occupied: Owns with a mortgage or loan
No Car:	
F989	All households
F991	Households (number of cars or vans): None

The four areas of deprivation were then calculated from this data using the below equations in Excel.

$$\%Overcrowding = \frac{F2380 + F2381}{F2376} \times 100$$

Figure 3: Equation for calculating %Overcrowding.

$$\%Unemployed = \frac{F248}{F256 + F260 + F557 + F559 + F248 + F267} \times 100$$

Figure 4: Equation for calculating %Unemployed.

$$\%Not\ Owner\ Occupied = 100 - \left(\frac{F2351 + F2353}{F2347} \times 100 \right)$$

Figure 5: Equation for calculating %Not Owner Occupied.

$$\%No\ Car = \frac{F991}{F989} \times 100$$

Figure 6: Equation for calculating %No Car.

Data cleansing

Data in MS Excel must be displayed in a certain way in order for QGIS to recognise it as what it is. It is therefore necessary to undertake data cleansing, and remove any excess characters or rows/columns of data which are superfluous. Every character must be either a text or a number, as symbols are not recognised by QGIS.

Creating a base map

Before adding any data to the GIS we must first establish a base map. To do this select "Plugins" from the top menu and select "Manage and Install Plugins".

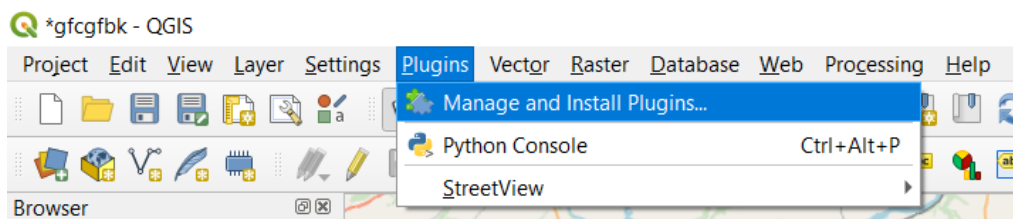


Figure 7: Demonstration of how to access "Plugins" menu.

Search for "QuickMapServices" and select "Install", then "Close".

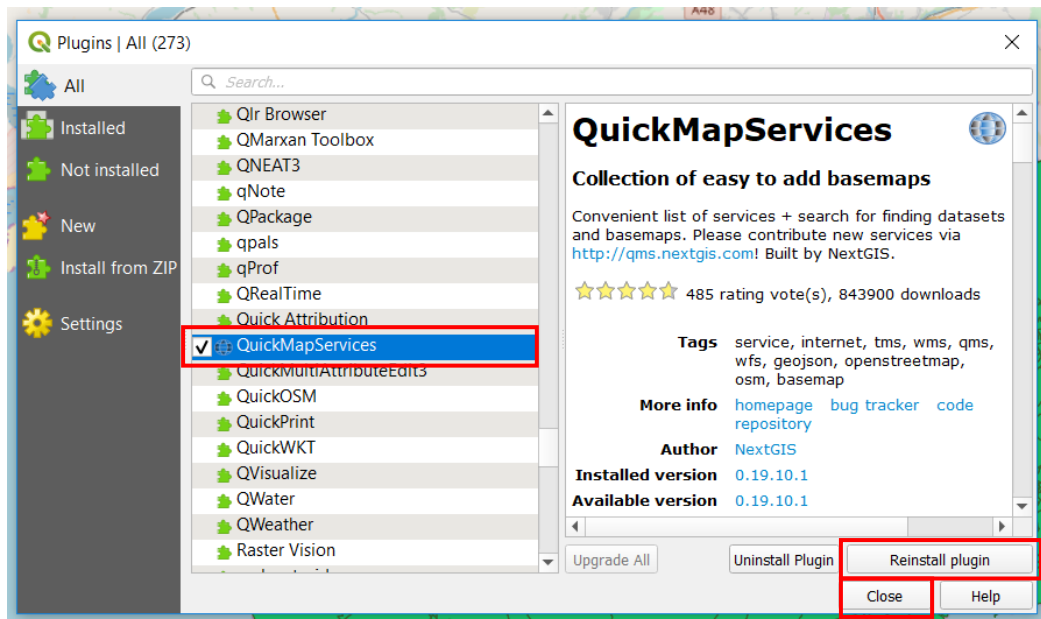


Figure 8: "Plugins" menu.

You will now have a map from which to base all other data points, based on the UK Ordnance Survey maps (Ordnance Survey, 2019).

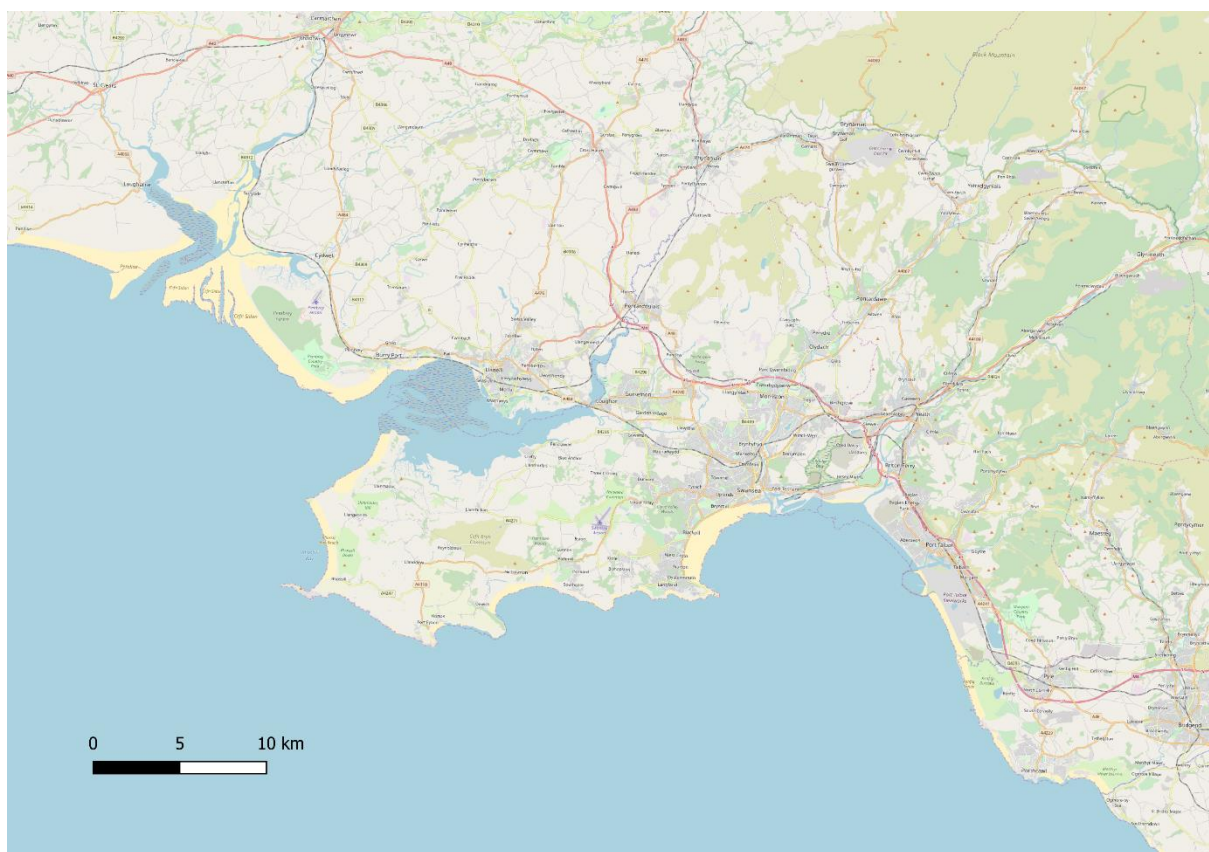


Figure 9: Ordnance Survey base map.

In this study, we are looking at data which is classified by UK postcode divisions, so we will also need a base map which shows these boundaries. To import this into QGIS select "Layer", "Add Layer" then "Add Vector Layer".

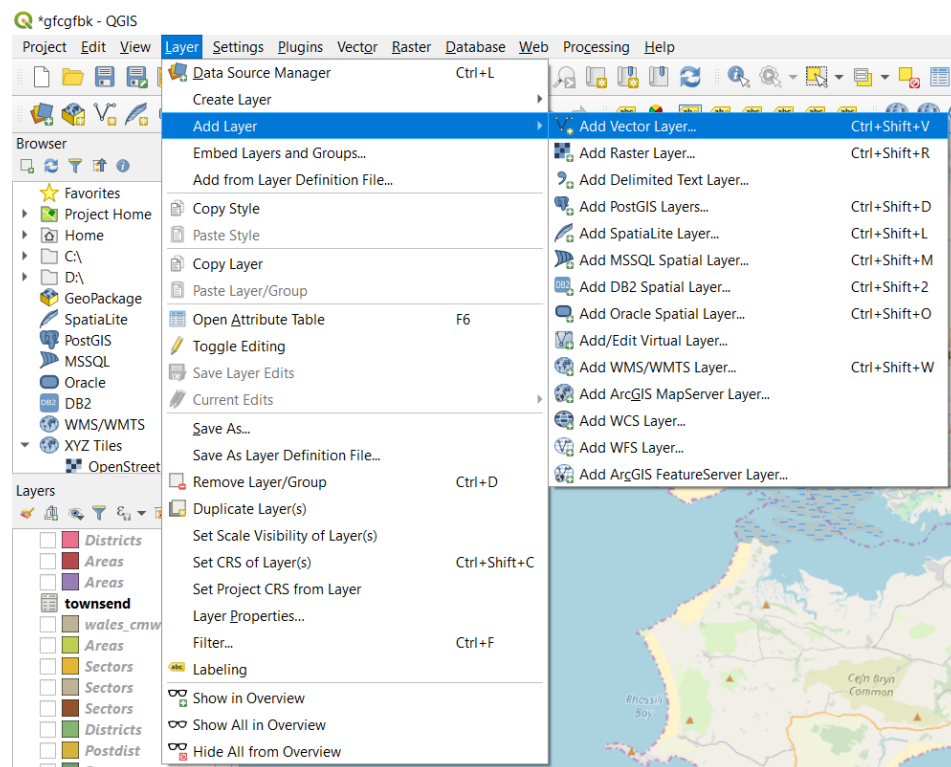


Figure 10: Demonstration of how to create a new layer.

Under “File name” select the relevant file from your Documents, this must be a .shp file. The X and Y field drop downs should correlate to the new layers coordinates, you will need to select the correct fields from the drop down. Select “Add” then “Close”.

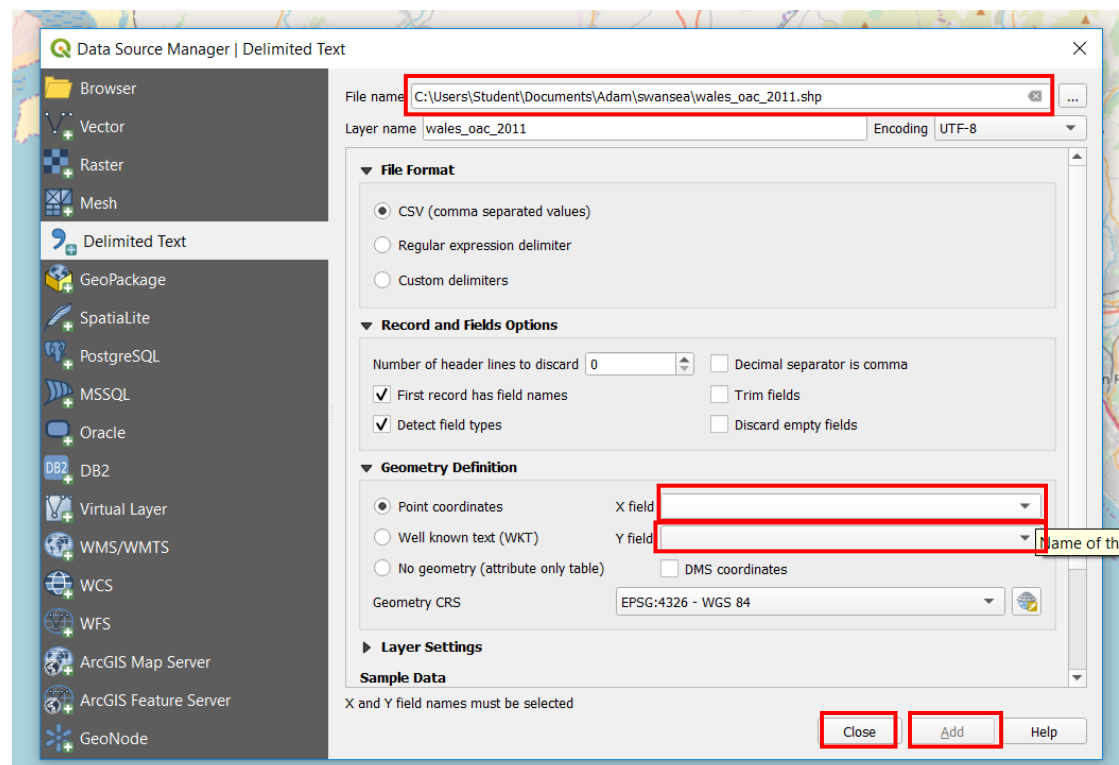


Figure 11: Demonstration of how to create a new layer.

This base map is the one which we will be joining data to in order to visualise it through QGIS.

Sense checking data

As the default coordinate reference system in QGIS is WGS84 (EPSG:4326), some layers may appear in the wrong location when first imported. It is necessary to change to British National Grid (EPSG:27700). To do this, right click the layer in the “Layers” tab, click “Set CRS” then “Set Layer CRS...”. This will open a new window.

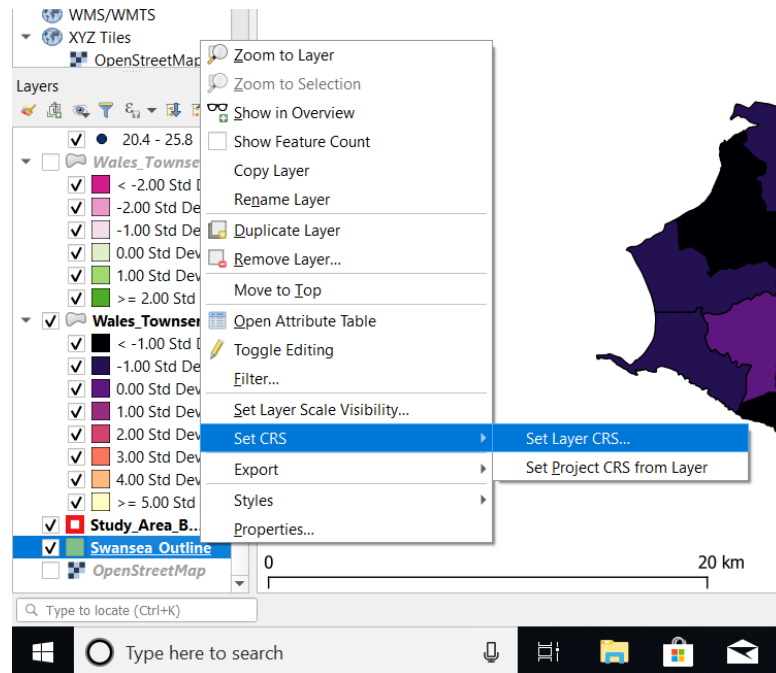


Figure 12: Demonstration of how to access the CRS selector.

Select “OSGB 1936/British National Grid EPSG:27700” then select “OK”.

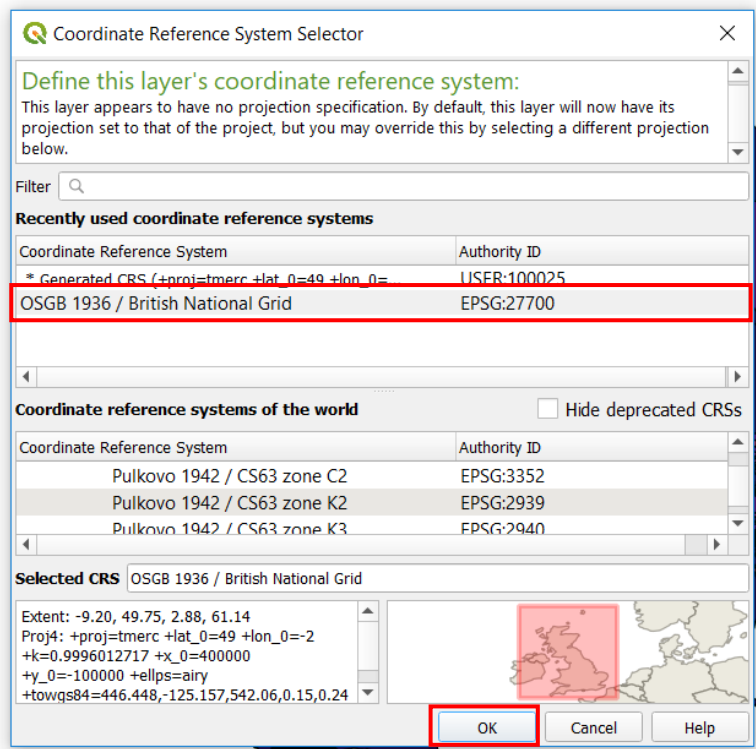


Figure 13: Demonstration of how to edit the CRS of a layer.

This is something simple which could be overlooked by someone who doesn't understand the data, but would lead to major errors.

Creating a join

Data from differing sources will most likely be tabulated in slightly different ways, the column titles may not match up exactly and the data will have to be "joined" to the base map layer once imported to QGIS. To do this, right click the base map layer in the "Layers" window and select "Properties".

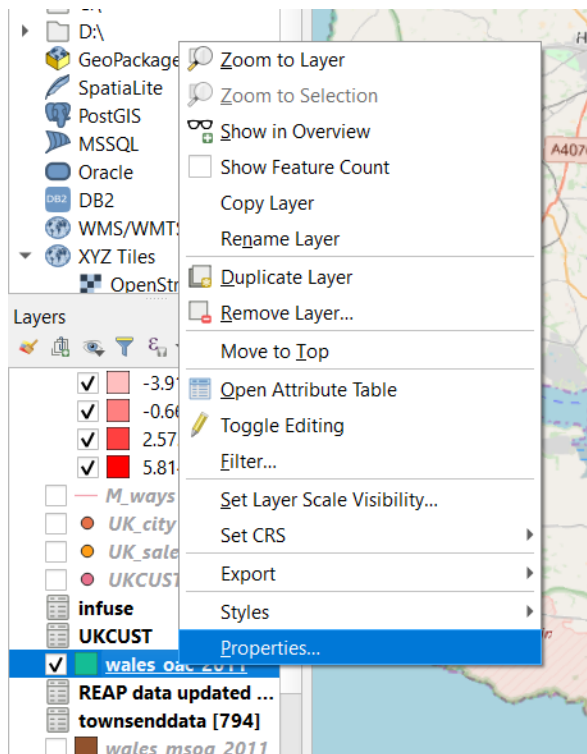


Figure 14: Demonstration of how to access the layer "Properties".

Select "Joins" and "Add new join".

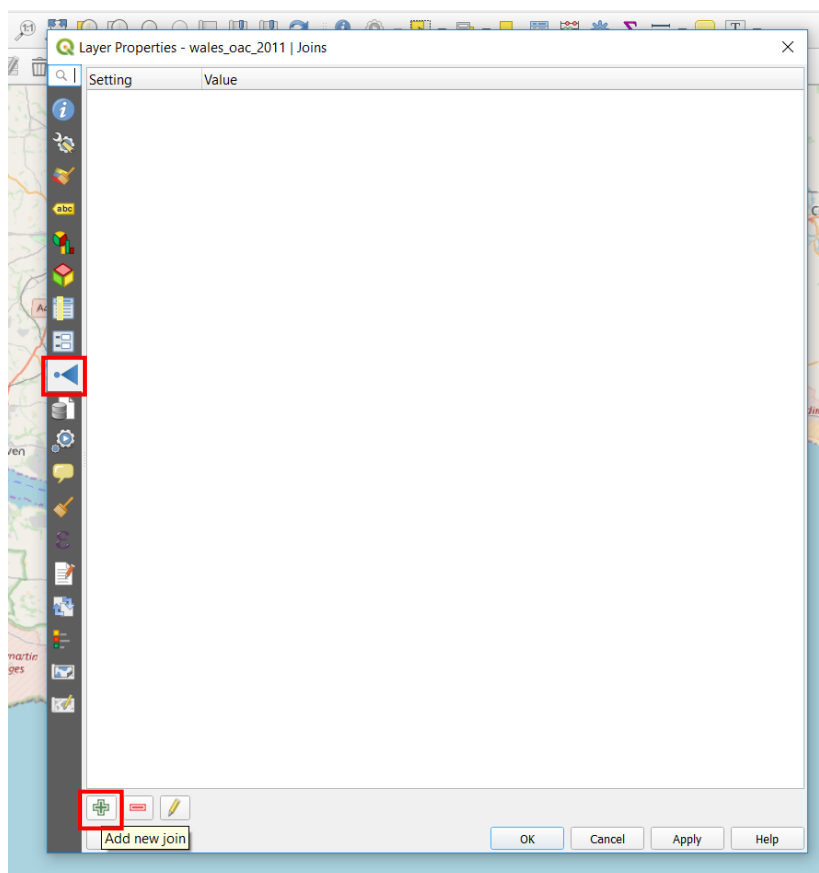


Figure 15: Join window.

Select your data source document from the “Join layer” drop-down. Select the field which you would like to join from this document from the “Join field” drop down. Select the field which you would like this to join to (i.e. the data which it matches, in this case GeoCodes, though this could be post codes or coordinates) from the “target field” drop down. The attribute that both layers have in common forms the basis of the join and so must be identical, this is the reason we cleanse the data to begin with. Ensure all of the fields which you would like to be visible on the base map layer have been ticked under the “Joined Fields” menu (in most cases this will be all of them). Select “OK”.

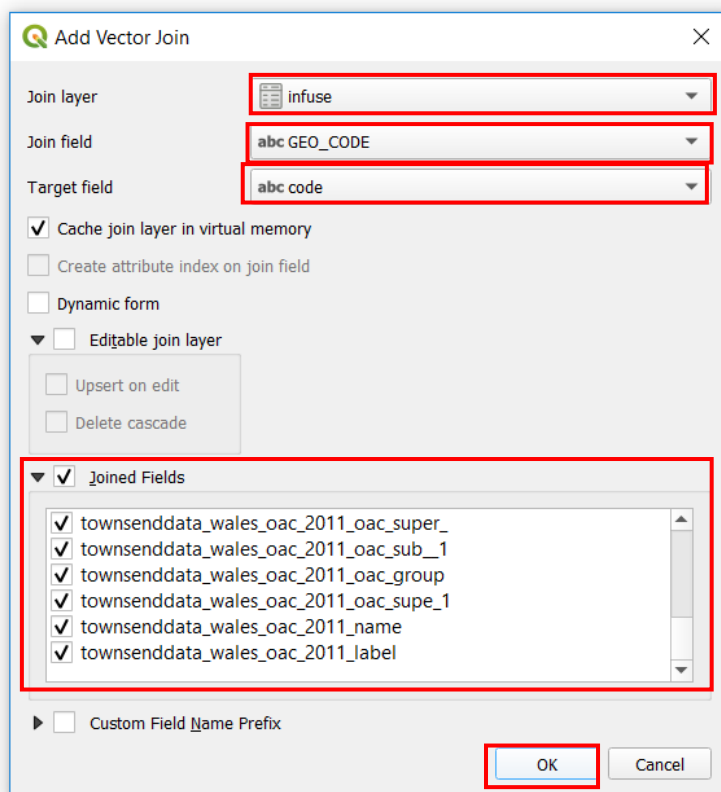


Figure 16: Demonstration of how to select fields for joining.

Select “Apply” then “OK”. The join will now appear under the Join tab under properties.

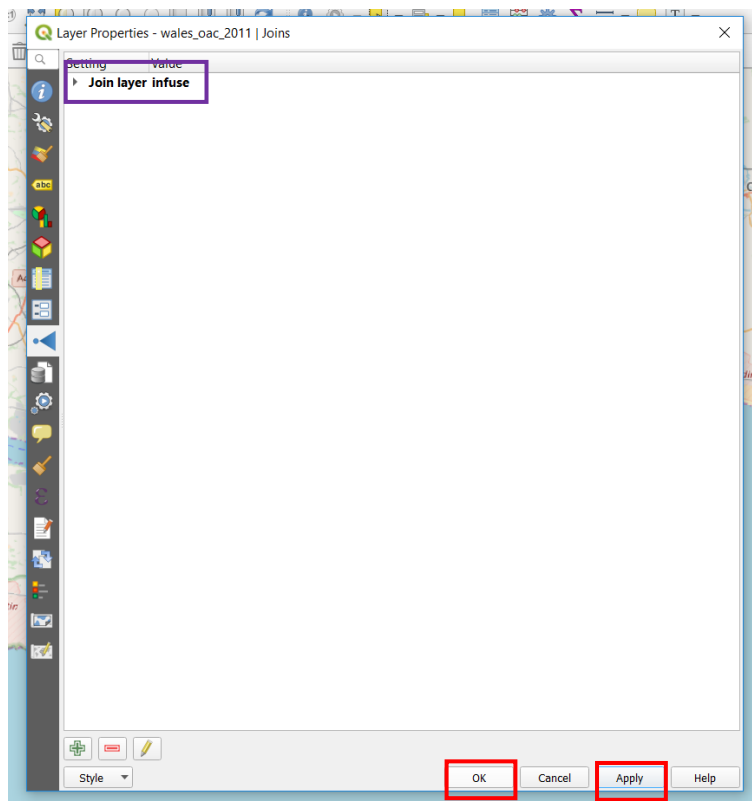


Figure 17: Demonstration of completed layer.

Now that you have told the two datasets that they are related, you need to visualise this data through the map. To do this, right click the relevant data layer and select “Properties” (as shown above). Go to the “Symbology” tab. The way in which you wish to display the data will determine your next steps (graduated symbology is more suited to absolute numbers, separating the data into unique classes e.g. high, medium, low, whereas category symbology is more suitable for categorical data e.g. male, female). The data used here as an example is from the UK Data Service 2011 Census and relates to the number of houses in each postcode area which are deprived in 0 areas. Therefore, a graduated visualisation is preferred. Select “Graduated” from the first drop down menu. The “Column” drop down relates to where the data is within the excel document. Select the relevant column. Change the “Colour” drop down to something relevant which doesn’t conflict with other data already displayed on the map. Select “Classify”, “Apply” then “OK”. The data should now appear on the map, and nested under the “Layers” tab.

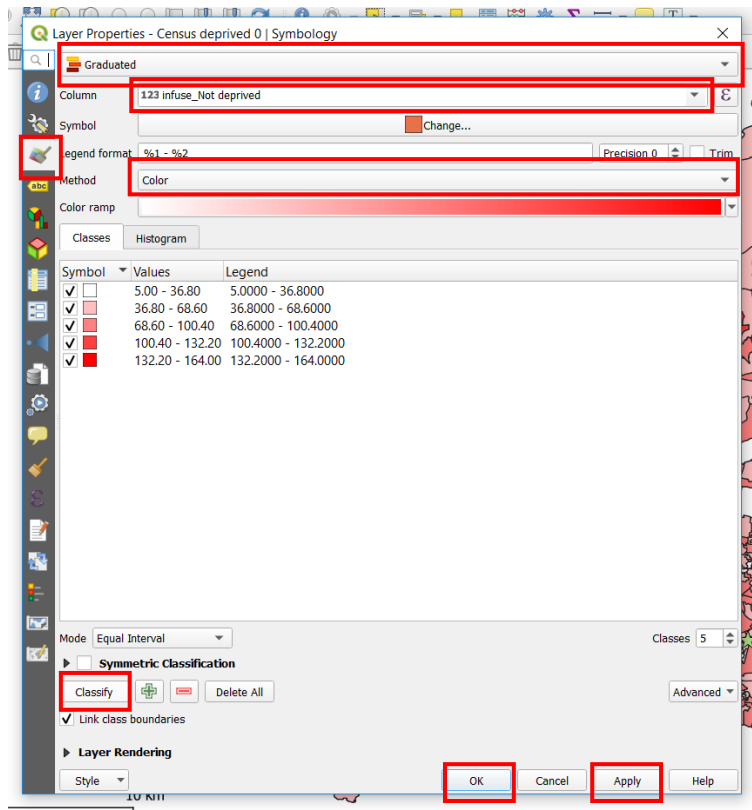


Figure 18: Demonstration of how to extrapolate further data from the join.

To add the next layer of data (in this case, the 2011 Census information giving the number of houses in each postcode area which are deprived in 1 areas) it is much more simple. Right click the layer you were just working on and select "Duplicate layer". From the "Column" drop down select the next layer of data you wish to visualise, change the colour to something different from the last layer, select "Classify", "Apply" then "OK".

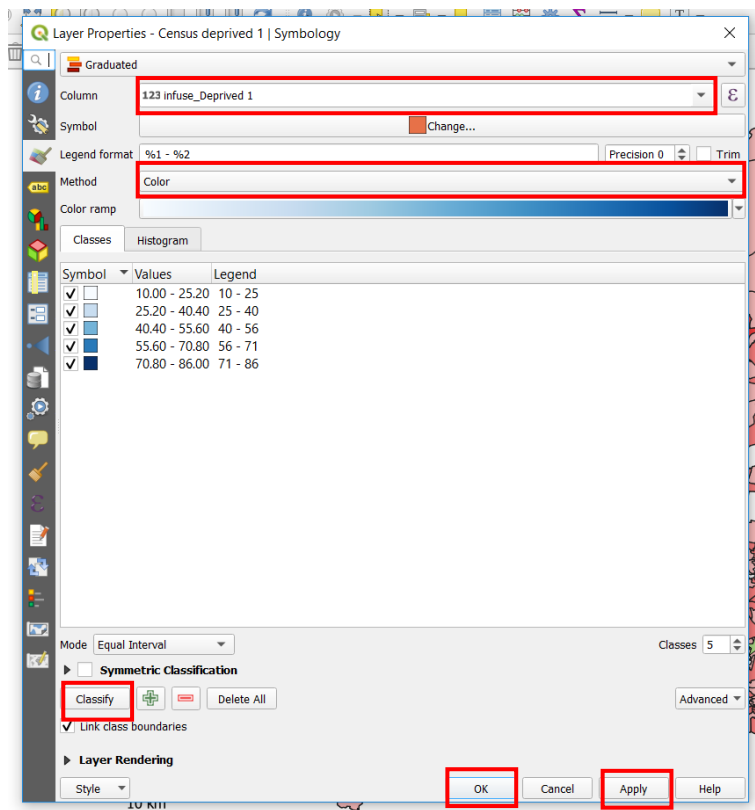


Figure 19: Changing the colour ramp of a given layer.

Rename the layer by right clicking on it in the “Layers” tab and selecting “Rename Layer”.

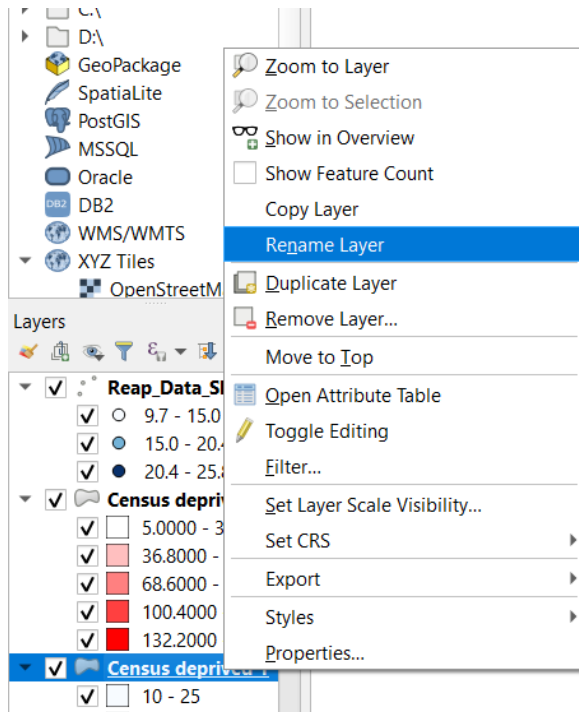


Figure 20: Renaming a layer.

Importing point data

The next step in this study is to import the point data, namely the Environmental Footprint calculations of 42 households in the SA1 and SA3 areas of Swansea. Create a new layer, as shown above, and

import the point data ensuring you select the correct x and y columns when prompted. Right click the point data in the “Layers” tab as shown above, and select “Properties”. Select the “Symbology” tab, and from the first drop down menu select “Single symbol”. This will then give you the option to display this data using a variety of symbols and colour options. Once you have made your selections, click “Apply” then “OK”.

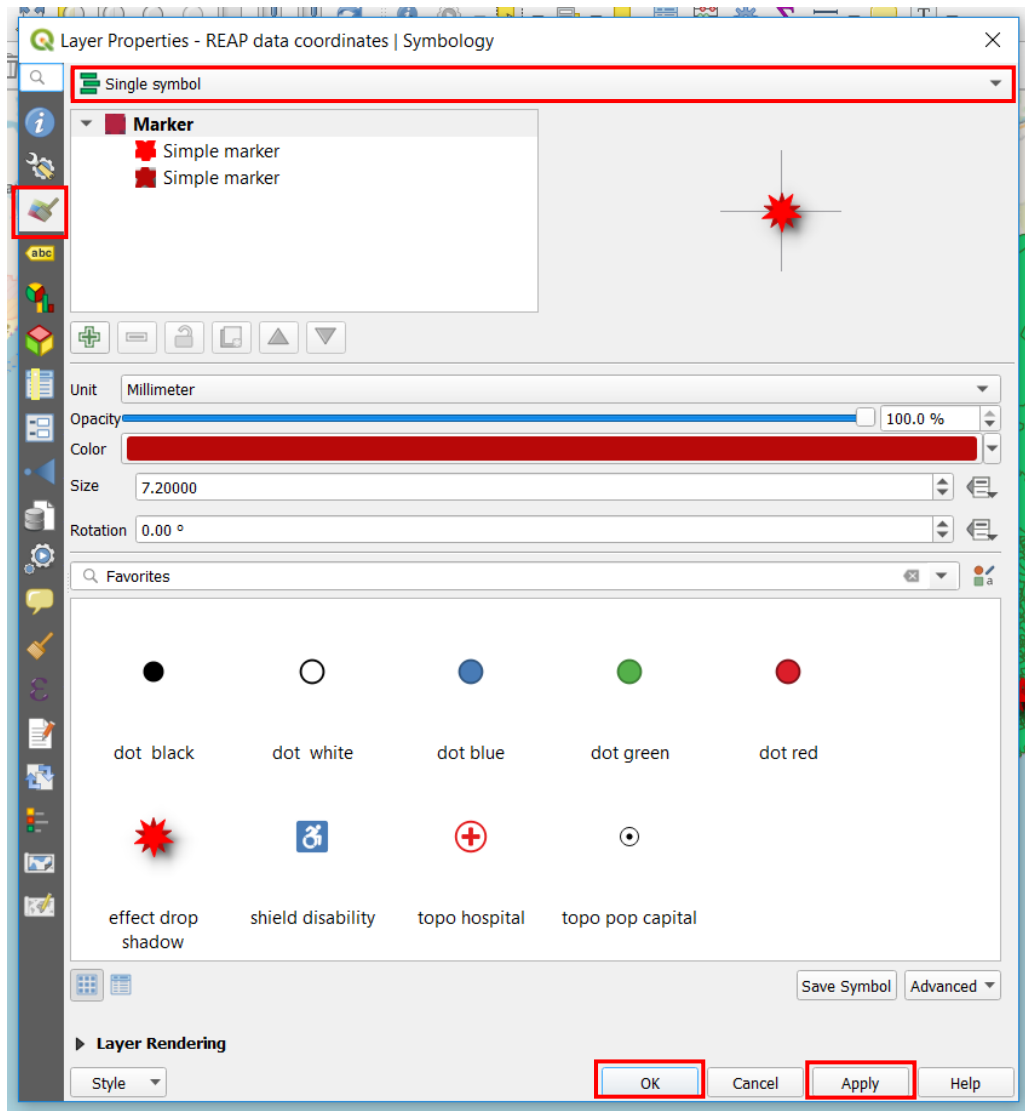


Figure 21: Symbolising a layer.

The data will now show up on your map, and will look similar to the below:

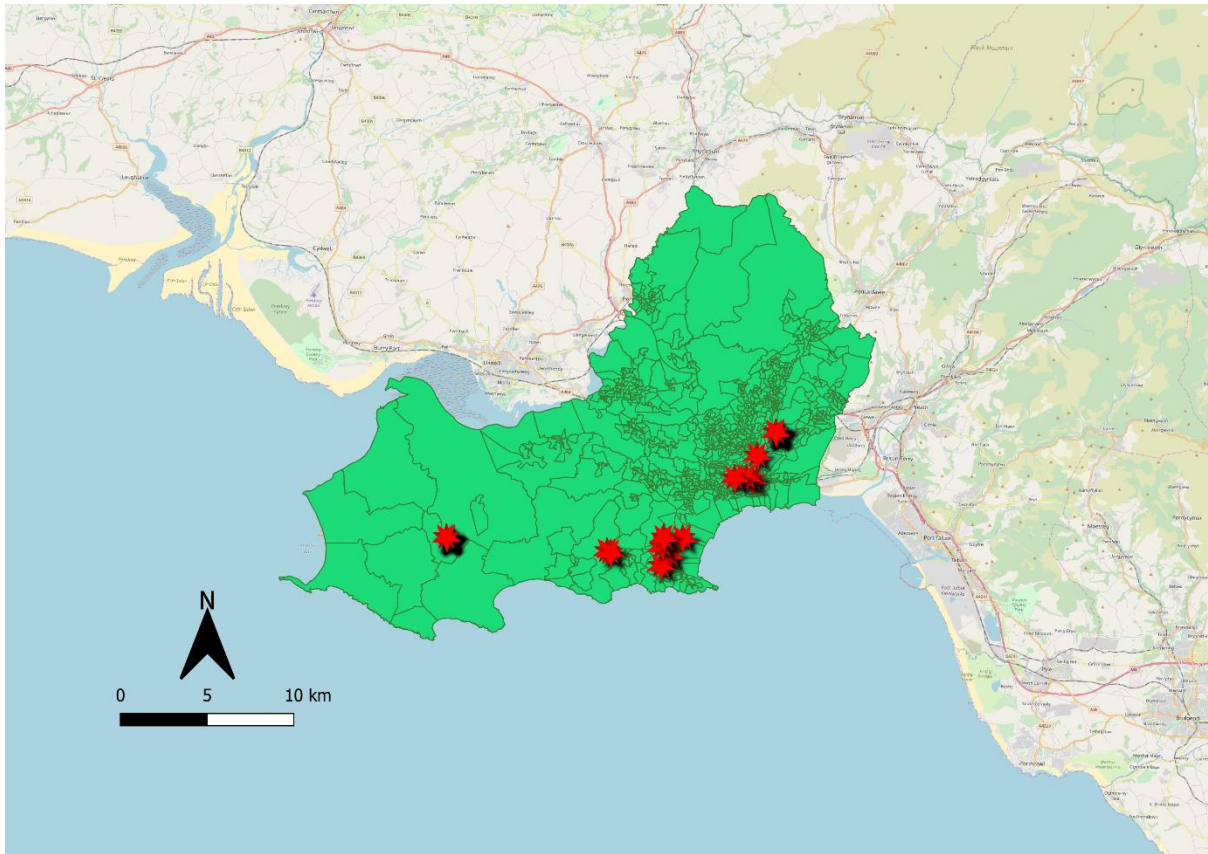


Figure 22: Ecological Footprints displayed on a map of Swansea.

Exporting maps

An important feature of all GIS systems is the ability to export maps so that they can be used as illustrative aids in reports. To do this, select “Project” then “New Print Layout”.

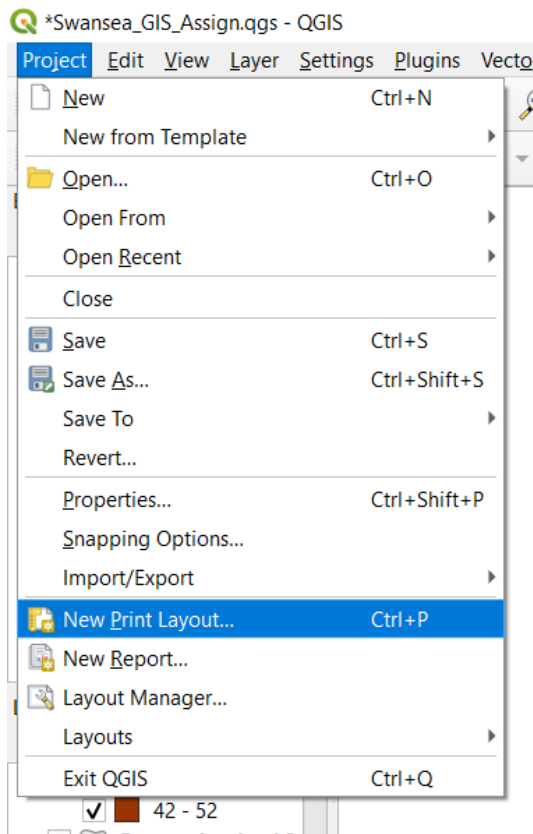


Figure 23: Demonstration of how to access "New Print Layout" window.

Create a name for your new image. Select "OK".

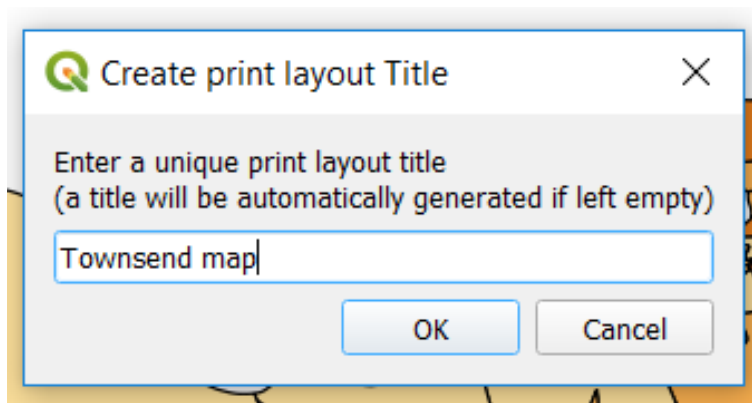


Figure 24: Titling a map before export.

This will open a new window. You can add items such as maps, scale bars, legends and symbols using the "Add Item" drop down.

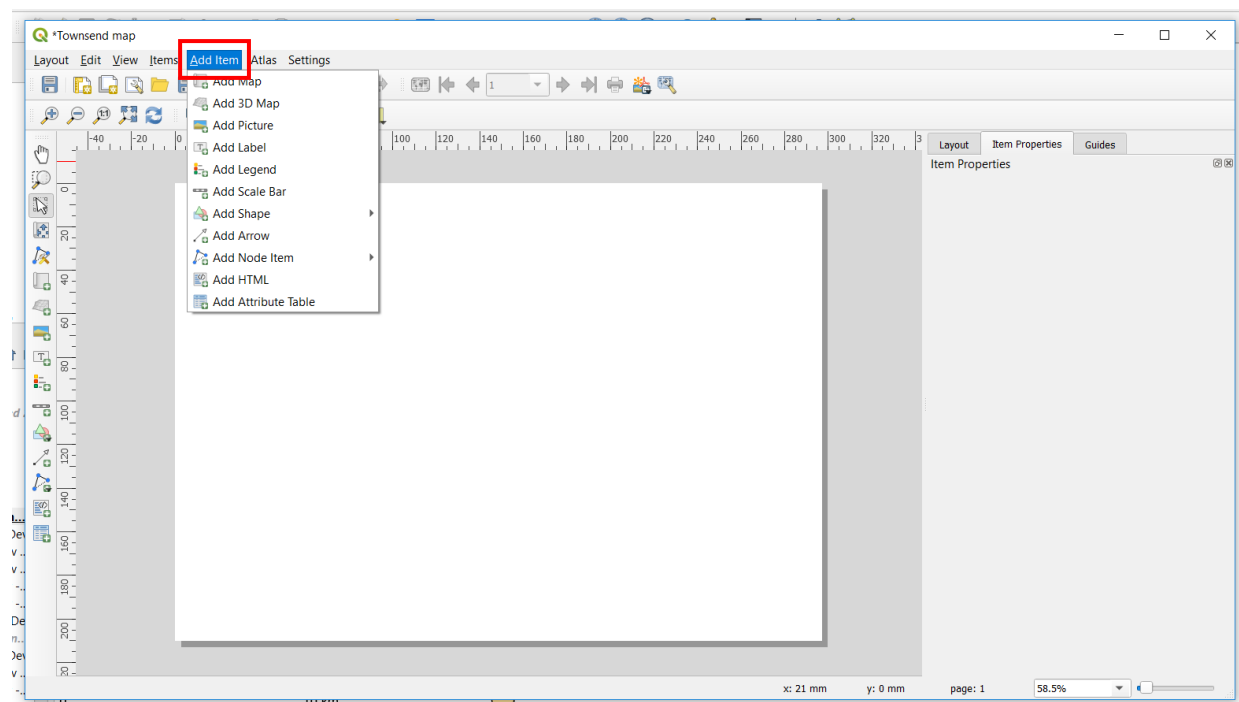


Figure 25: Demonstration of how to export a map.

Once you have finished adding items to the map, select “Export as image” and save to your Documents.

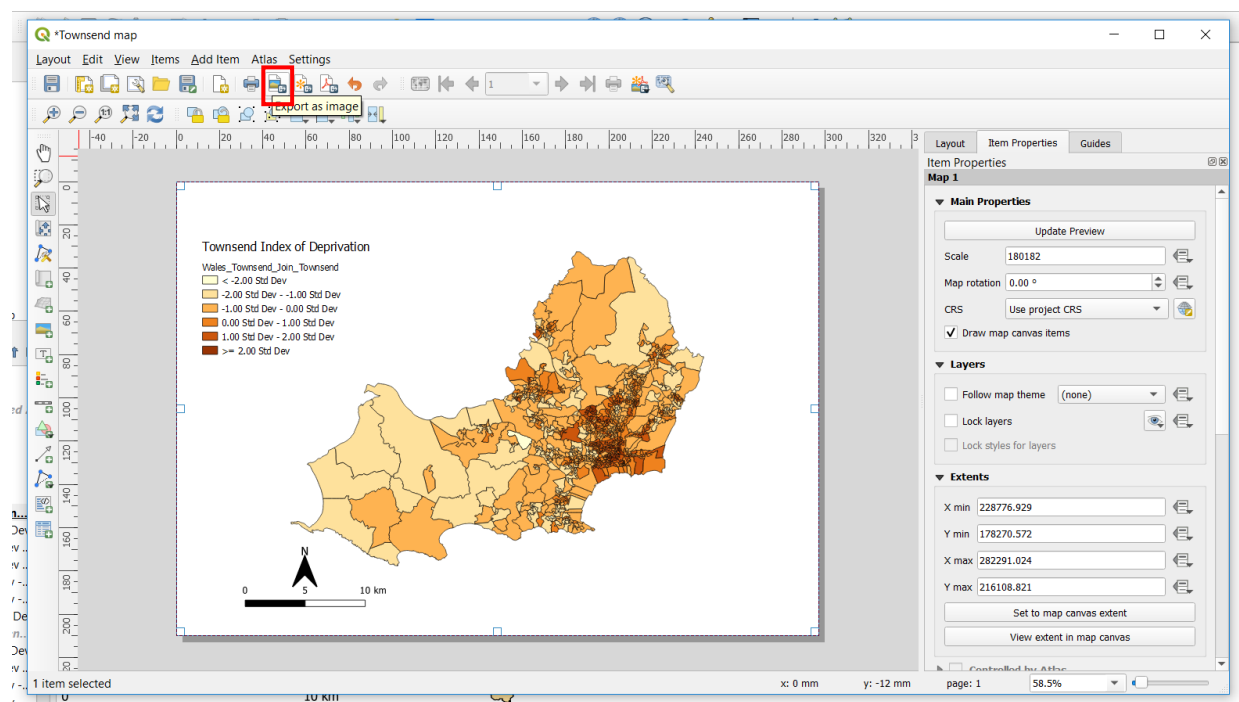


Figure 26: Demonstration of how to add legend, scale bar and North arrow to a map before export.

The result will look like this:

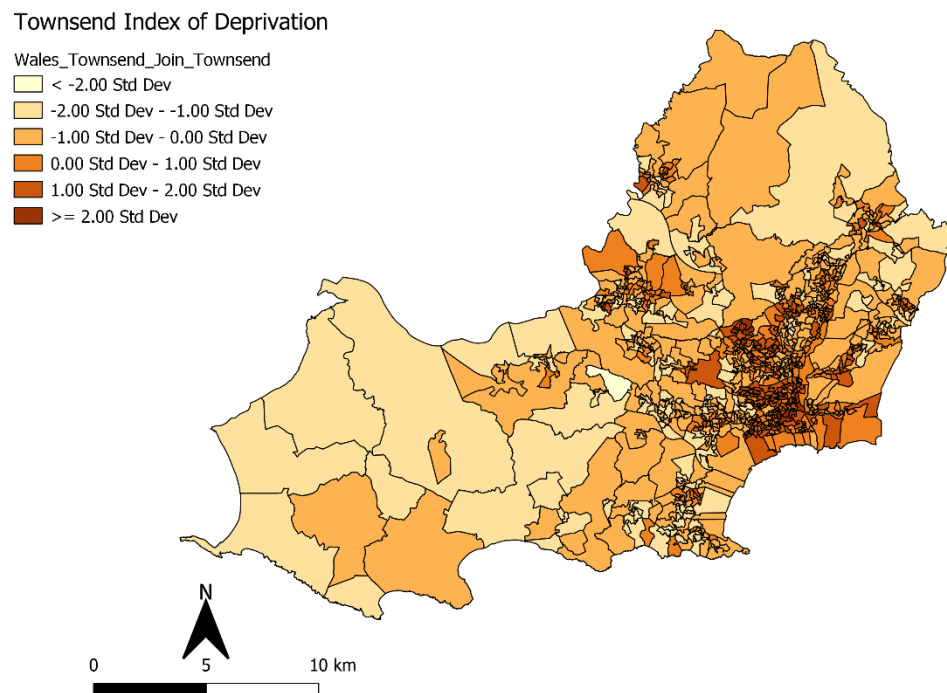


Figure 27: Townsend Index of Deprivation displayed on a map of Swansea.

Results

One way to visualise the Census Data through MS Excel would be to produce a pie chart, as below.

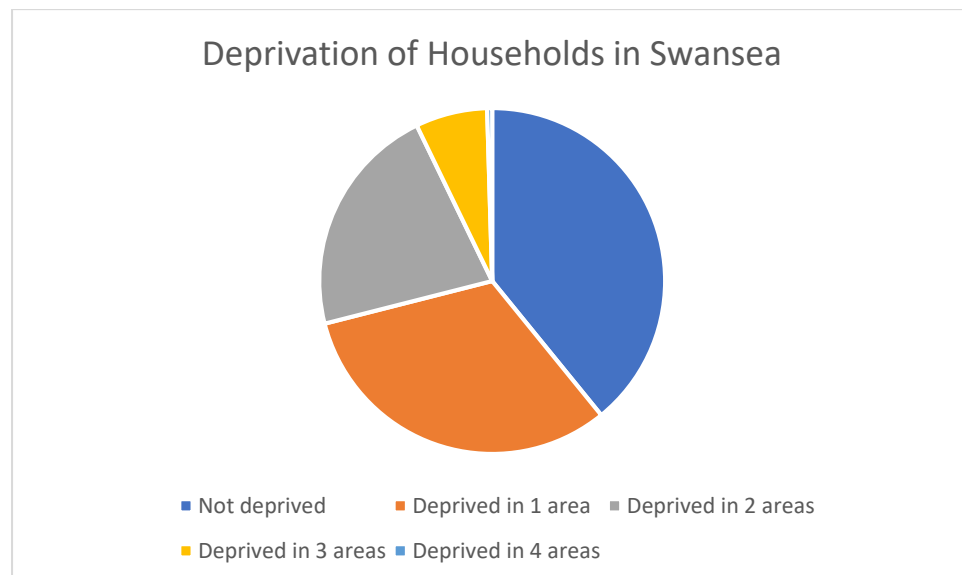


Figure 28: Deprivation of households in Swansea displayed as a pie chart.

The same data could be visualised through QGIS as five maps, as below.

Swansea Households Deprived in 0 Areas

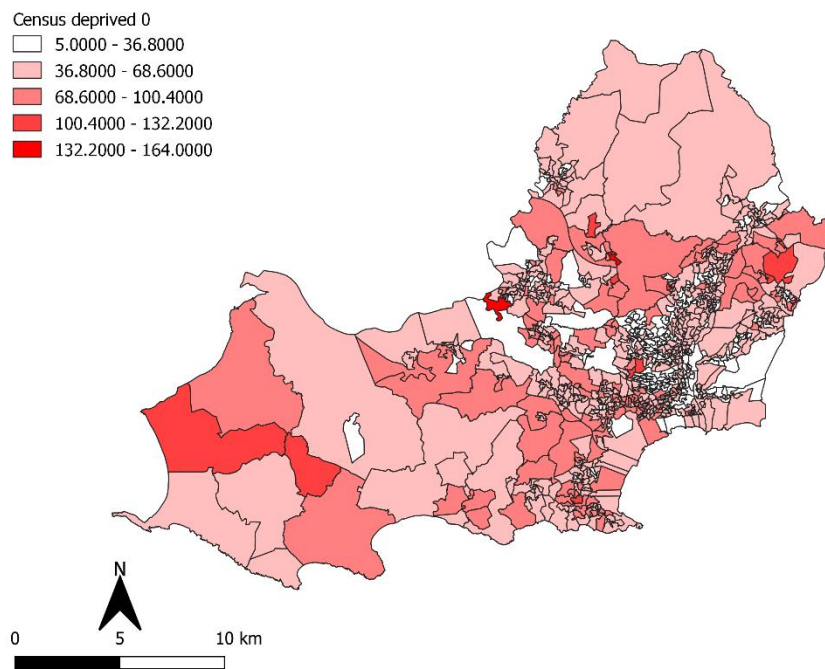


Figure 29: map of Swansea households deprived in 0 areas.

Swansea Households Deprived in 1 Area

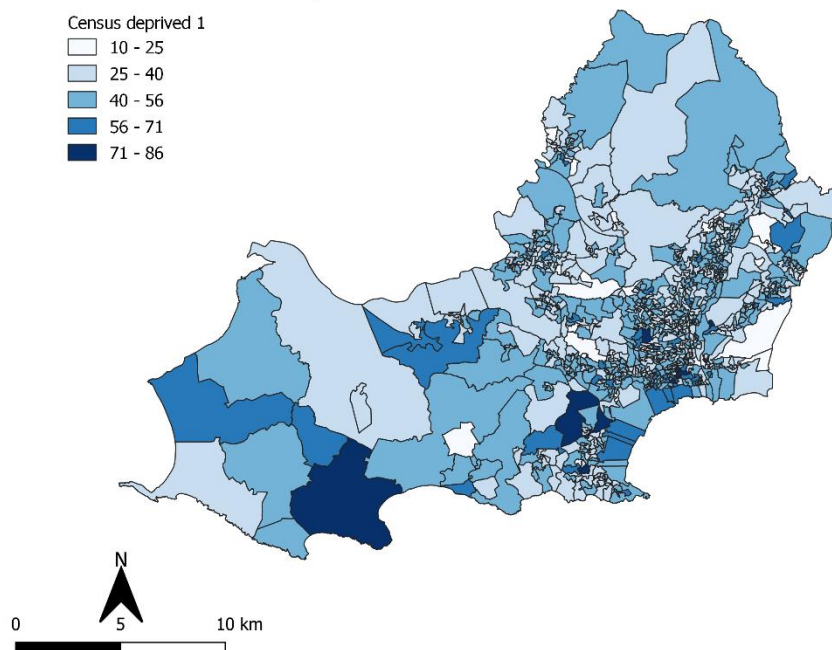


Figure 30: Map of Swansea households deprived in 1 areas.

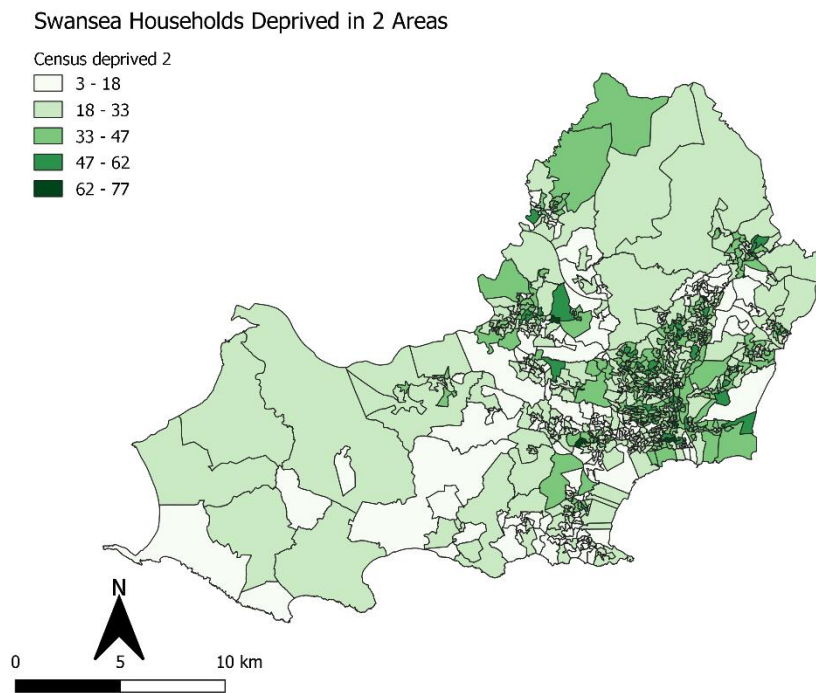


Figure 31: Map of Swansea households deprived in 2 areas.

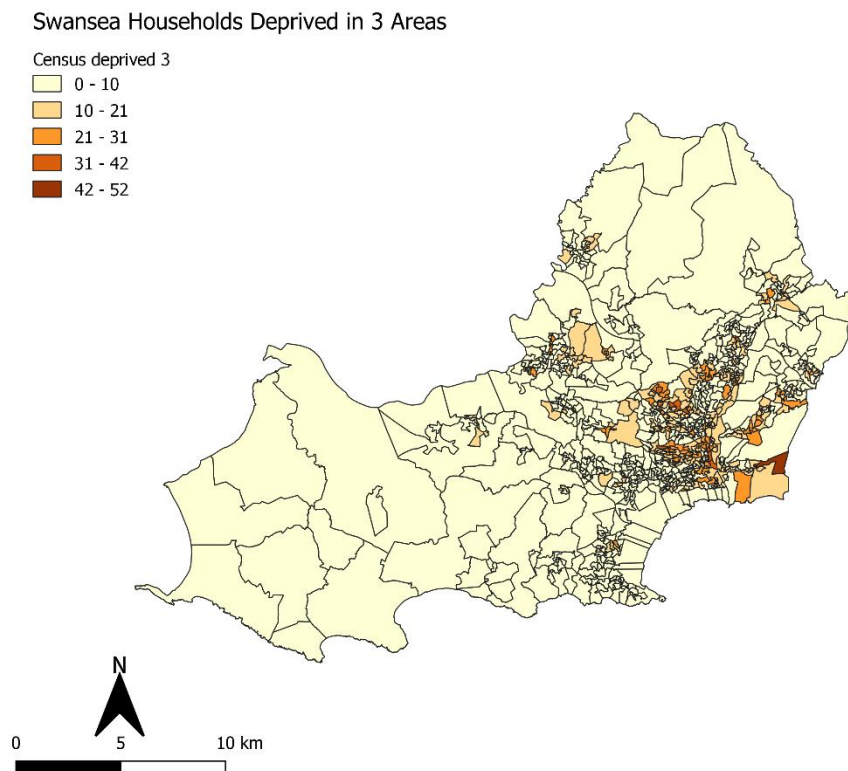


Figure 32: Map of Swansea households deprived in 3 areas.

Swansea Households Deprived in 4 Areas

Census deprived 4

- 0 - 3
- 3 - 5
- 5 - 8
- 8 - 10
- 10 - 13

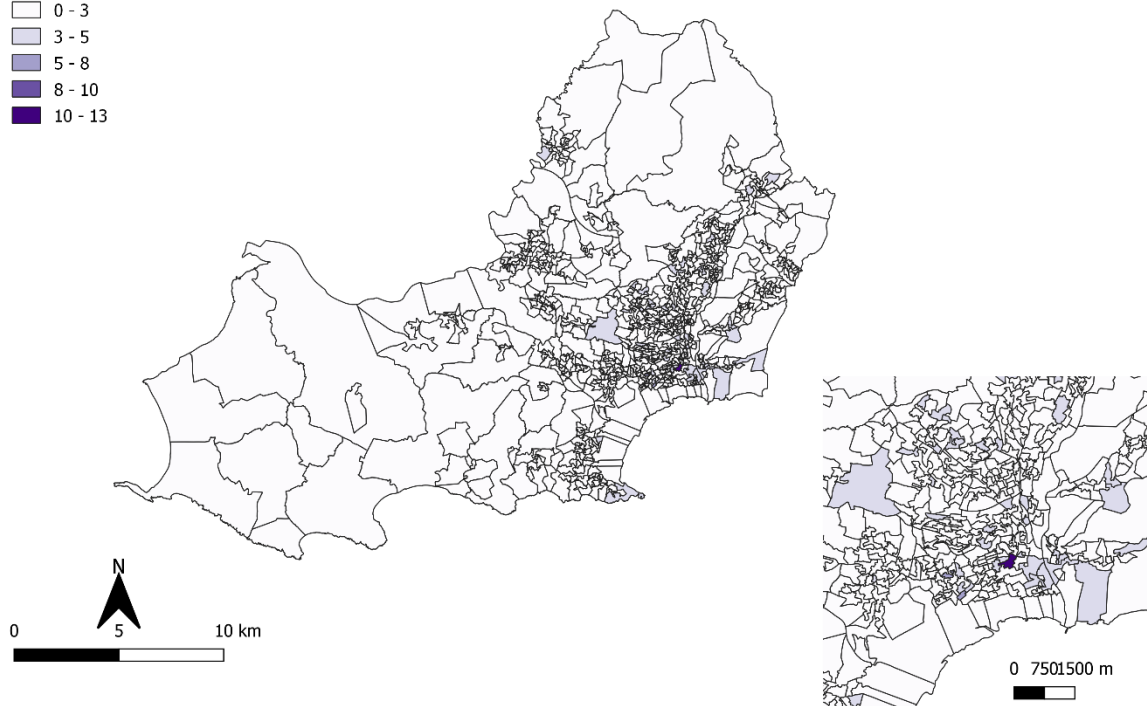


Figure 33: map of Swansea households deprived in 4 areas.

The benefit of displaying this data through QGIS is that you can then see exactly which areas are affected by deprivation, which in this case is Swansea City itself (SA1). The downside of both MS Excel and QGIS' representations of this data is that it does not show precisely which type of deprivation an area is suffering from.

The Townsend Index can infer slightly more, as it can be further broken down into its four constituent parts (unemployment is not shown), as seen below.

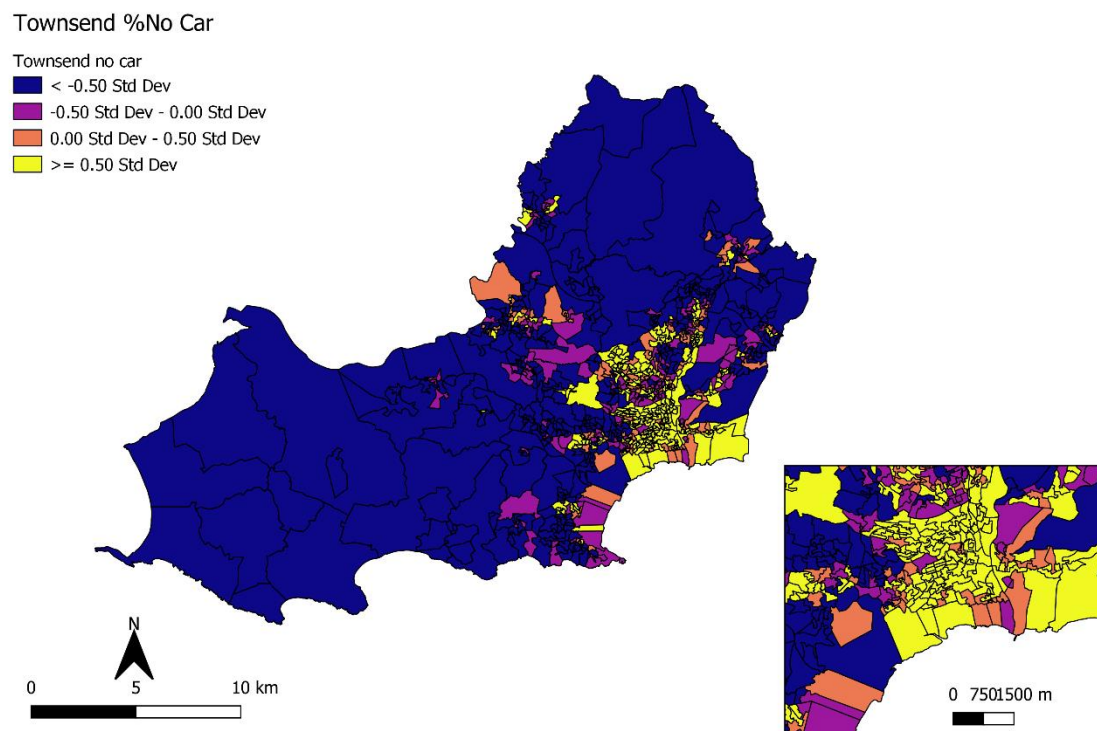


Figure 34: Map of Swansea with Townsend %No Car data.

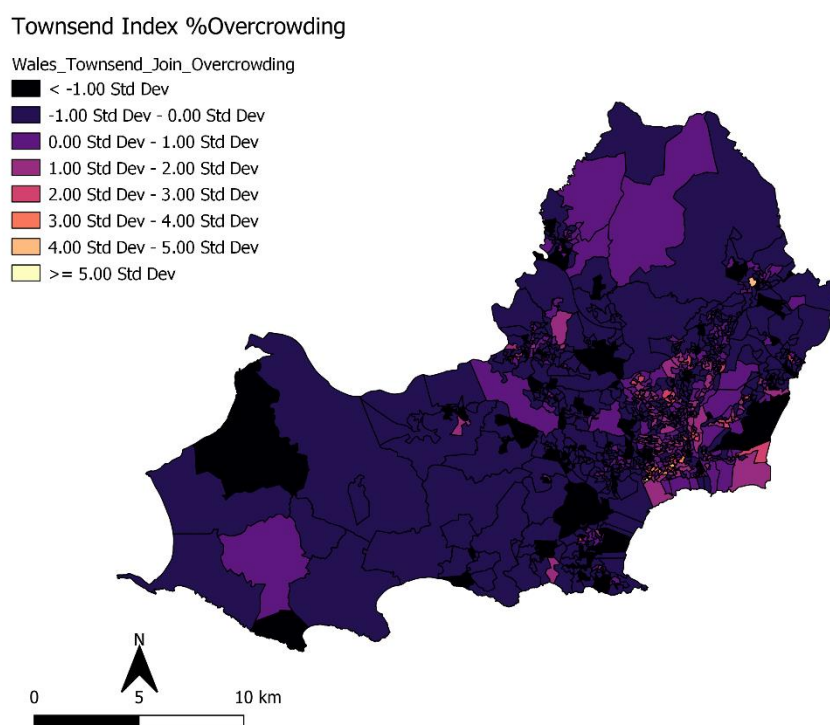


Figure 35: Map of Swansea with Townsend %Overcrowding data.

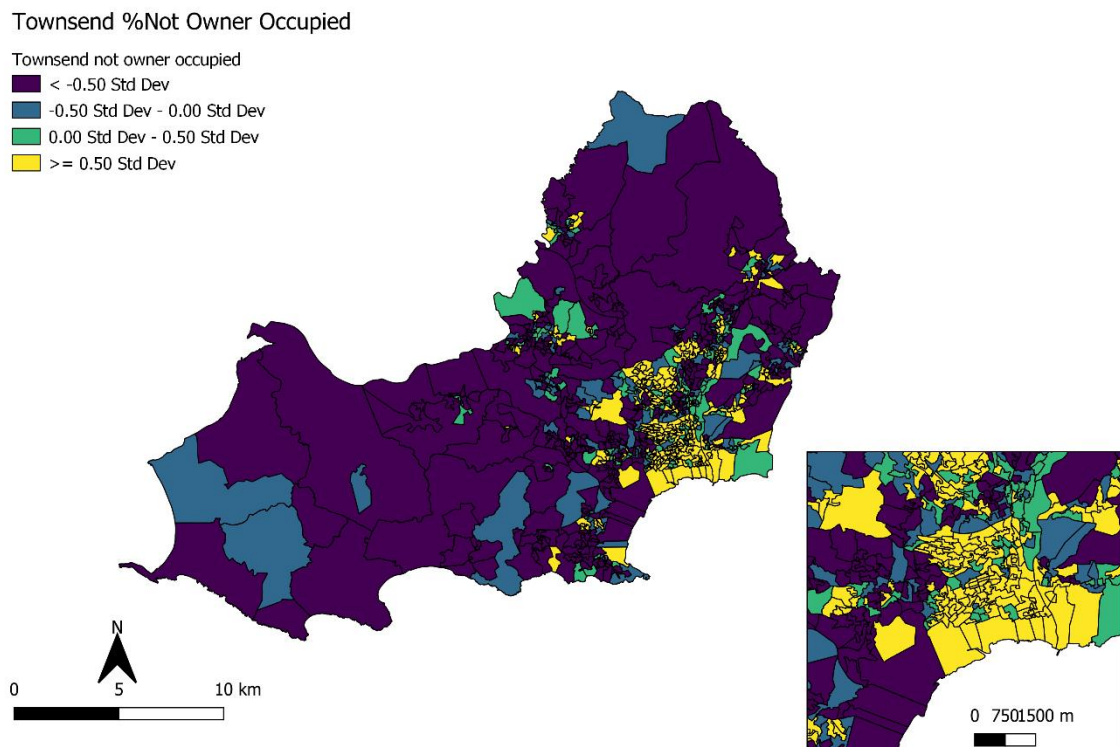


Figure 36: Map of Swansea with Townsend %Not Owner Occupied data.

Plotting the Ecological Footprint data from REAP Petite onto a map showing the Townsend Deprivation index is particularly telling, as it shows that those households surveyed in the SA1 area have, for the most part, smaller Ecological Footprints than those surveyed in the SA3 area.

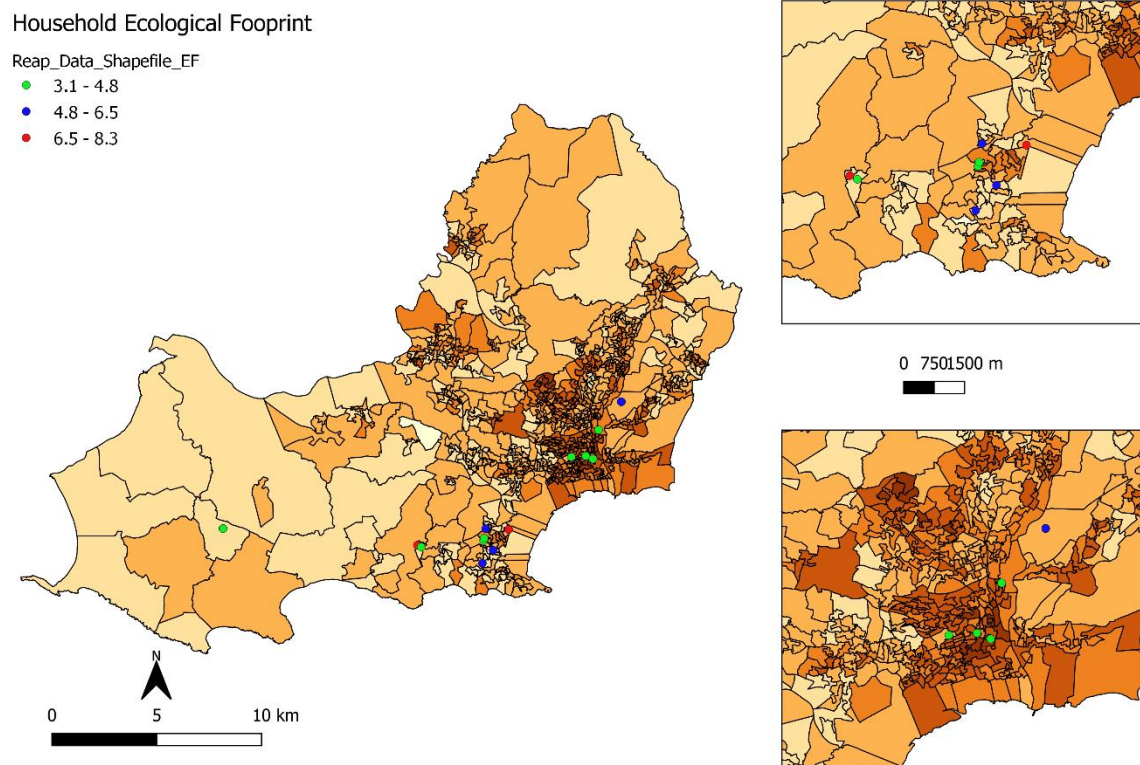


Figure 37: Map of Swansea with household Ecological Footprint data displayed over Townsend deprivation data.

When comparing the recycling rates of households in SA1 and SA3, however, no obvious difference can be seen.

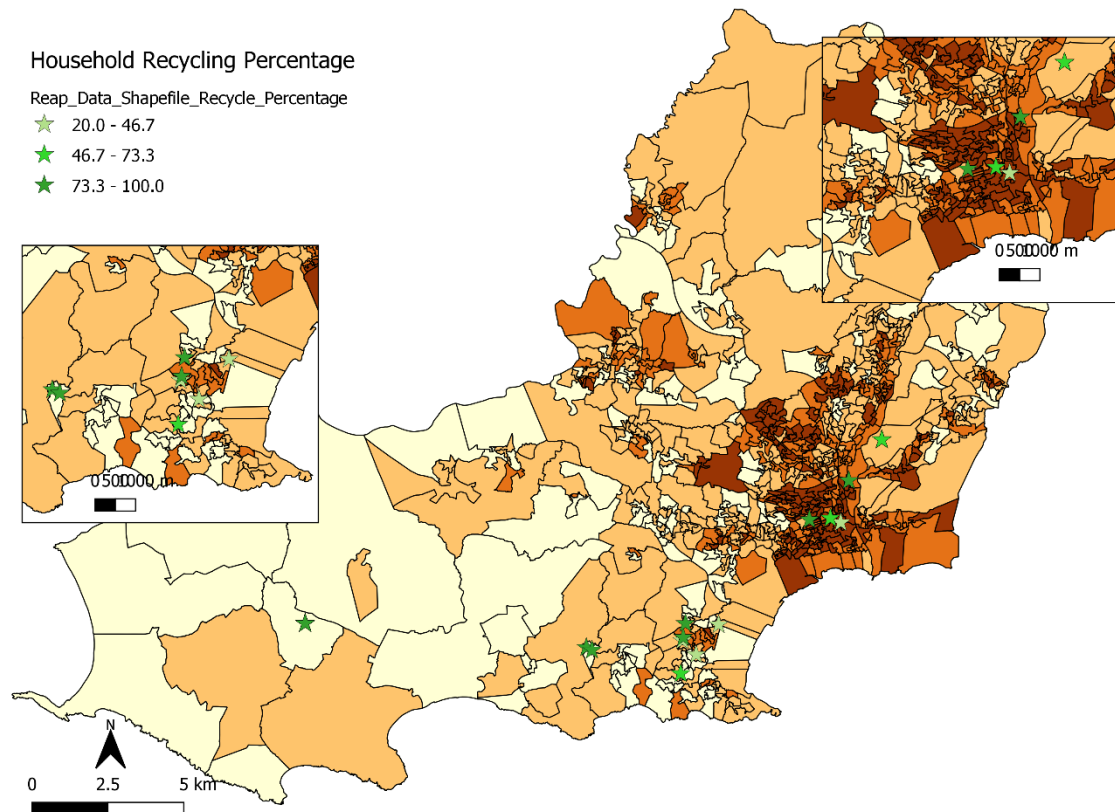


Figure 38: Map of Swansea with household recycling data displayed over Townsend deprivation data.

Discussion

The Townsend Index, as a measurement of deprivation, leaves a lot to be desired. By focussing only on four areas (car ownership, overcrowding, tenure and employment) to determine an areas deprivation score, it does not give a particularly comprehensive overview of deprivation in that area. A measurement system is only as good as the indicators which it relies upon, and those utilised by the Townsend Index are inadequate. For example, the lack of car ownership could be indicative of a low disposable income, or it could be indicative of a strong public transport network which negates the need for private car ownership. A better alternative would be to use the Welsh Index of Multiple Deprivation, which relies on a much broader range of indicators to calculate it's final ranking. (Welsh Government, 2019)

GIS software can only be as good as the data it relies on. This report provides yet another case-study for the use and proliferation of FOSS as a tool for conservationists and decision makers. The findings support the view that FOSS is very flexible, but possibly slightly less user-intuitive than similar, proprietary software (Maurya, Ohri & Mishra, 2015). No comparisons can be made, however, as only QGIS software was used. A major benefit of QGIS is its layering capabilities which allow the user to illustrate multiple datasets at once but also isolate as required. Data is communicated and displayed in a way that is easily and quickly understood, even by those with no past experience of interpreting GIS maps. Also, as QGIS can use any data with a spatial attribute it can be used in almost every discipline, conservation or otherwise.

Conclusion

The results of this study show that QGIS is a valid and effective way of visually displaying data relating to deprivation and Ecological Footprinting. QGIS is able to display this data in a way which provides added depth and layers of information not provided by MS Excel or other, tabulated and graphical methods. The results show that households Ecological Footprints are higher in those areas which experience least deprivation in Swansea, South Wales.

References

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