LAB 1
THE PROJECT: SPATIAL ANALYSIS FOR REAL ESTATE MARKET INVESTMENTS

Each lab is consisted of two sections, namely Section A (ArcGIS) and Section B (GeoDa). Section A provides step-by-step instructions on how to solve the lab exercises using ArcGIS. Interpretation of the results and concluding remarks are also presented. Section B applies GeoDa functionalities to solve the same exercises. As such, readers may opt to solve the lab's exercises either using a leading commercial software or a well-established open-source freeware. The interpretation of the results as well as the conclusions related to the analysis are not repeated in Section B, as they are presented in the related Interpreting Results paragraphs of Section A. The reader should study these sections carefully, as they are independent of the software used. In addition, Overall Progress and Scope of Analysis sections precede Sections A and B to offer a better understanding of the spatial analysis process as well as the motivation for the analysis of each lab.

Overall Progress

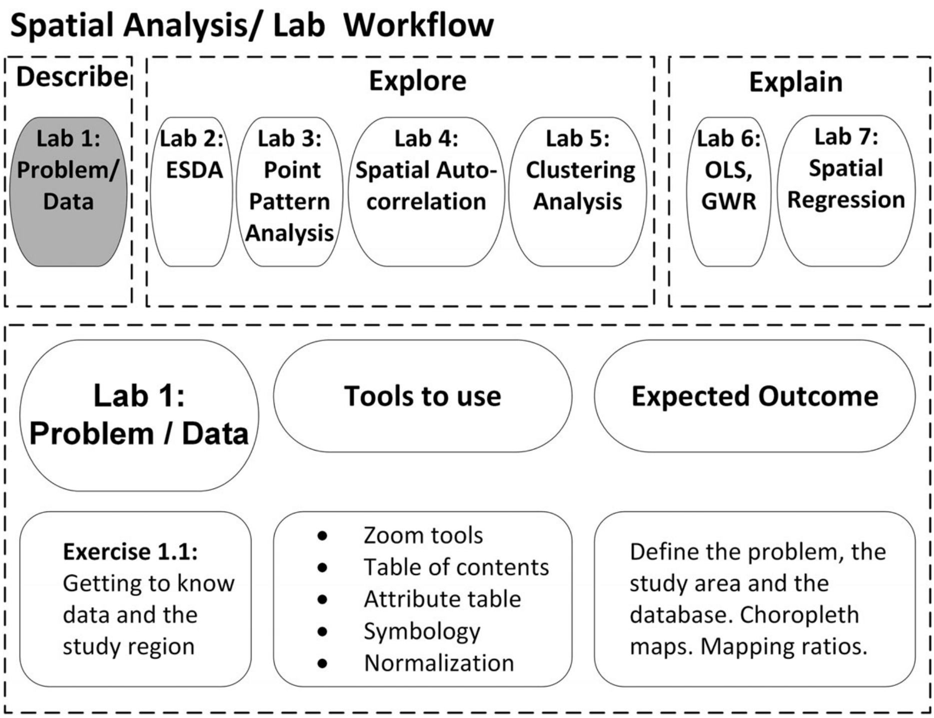


Figure 1.7 Lab 1 workflow and overall progress.

Scope of Analysis

A realtor wants to offer the best options to its clientele other than that of just listing its properties. As the company's moto is "location, location, location," it

Table 1.2 Project objectives and methods per lab.

No	Objectives	Methods	Lab
1	Location: High income	Mapping, Spatial autocorrelation	2,4,5
2	Location: Low Crime	Mapping, Centrographics, Spatial autocorrelation	3,4,5
3	Clustering: High spenders	Clustering	5
4	Modeling: Identify drivers	Regression, Spatial regression	2,6,7

provides geographical and socioeconomic data (for example, census data, income data, crime data) and offers location analytics through advanced spatial statistics and GIS. By conducting such an analysis, the company aims to become more competitive and also more reliable by answering tailored questions from each client regarding their unique investment needs. The more information available on location and surrounding areas, the higher the probability of successful investments. Spatial analysis offers the tools and mathematical background required to provide quantitative answers visualized through GIS maps that are usually better than personal opinions and general beliefs about a place.

This project deals with the following task. An investor seeks the best location to establish a successful new coffee shop and turns to the real estate company for advice and consultation.

Excluding rent and related costs (see Box 1.4), the investor is primarily interested in finding an appropriate neighborhood based on the following objectives (see Table 1.2):

1. As the service provided would be of premium quality, the coffee shop should be located in an area whose residents (i.e., potential clients/target group) have **high annual incomes**.
2. The coffee shop should be located in an area of **low crime**.
3. The target group should be likely to spend more money than average for expenses, including coffee-related products. **High spenders** should be identified.
4. The **socioeconomic drivers** behind people’s monthly expenses (including those for coffee-related services) should be identified.

The fourth objective is not directly linked to finding an optimal location as described in the first three main objectives. It focuses on identifying the spatial relationships that can be used for modeling, market penetration and clientele analysis. Such an analysis should include detailed variables such as consumption preferences, everyday habits, type of job and the amount of money spent on coffee in coffee shops. For educational reasons and to keep the analysis brief, we will focus on primary socioeconomic variables.

Box 1.4 A complete study would also include such factors as the location of competitors, rent and related costs, access to public transport (i.e., subway), the budget of the investment, the number of daily passersby, the size of the

Box 1.4 *(cont.)*

permanent population and the number of people working in nearby offices. It would be infeasible to answer these questions within a book and this project addresses only those dealing with space. The results can then be integrated into a market analysis conducted by marketers or business specialists to build a robust business and spatial plan. Spatial planning is key for success, not only in business but also in the implementation of national, regional and local policies on various issues, such as education, health, labor, emergencies and public administration.

In our case study, although the four objectives/questions seem simple, the analysis might prove endless (which is possible in spatial analysis). We will concentrate on a relatively large set of important questions and provide advanced modeling options. To address these questions, we will use many spatial analysis methods, such as exploratory spatial data analysis, spatial autocorrelation, data clustering, spatial clustering and spatial regression (see Tables 1.2 and 1.3).

The spatial analysis will go through three steps – Describe, Explore and Explain – while answering three basic questions: "What?" "Where?" and "How/Why?" (see Figures 1.1 and 1.7).

- For the **"What?"** set of questions, we will study the status of specific variables. For example, what is the mean income of the study area? What is the population with incomes higher than a specific value? Are there income outliers? This provides an initial understanding of the socioeconomic profile of the study area. Combined with exploratory spatial data analysis and related mapping techniques, it will offer a preliminary indication of how the variables are distributed in space.
- Then, we will ask **"Where?"** questions. Where are the areas with low/high income? Are there spatial clusters of areas with high income values? Is there a crime hot spot? These type of questions will provide a solid analysis based on spatial statistics that quantify results as being significant or not and also identify interesting spatial patterns that would not be detectable otherwise.
- Finally, the analysis will delve deeper by answering **"How/Why?"** questions. Several regression and econometric models will be created to model monthly expenditures (independent) based on a set of dependent variables (e.g., location, income).

Data

The study area is the city of Athens, Greece (referred to as the "city" hereafter). The spatial data refer to the postcodes of the city (polygons; see Table 1.4). The socioeconomic data refer to the 2011 census (see Table 1.5). Some of the census data are original, and some have been rescaled for reasons of confidentiality.

Tasks

The main analysis tasks are presented in Table 1.3.

Table 1.3 Project tasks per lab following the describe–explore–explain workflow.

Task	Lab	Tools to perform task	Why performing task
What (describe)			
Dataset and study area. Create and map ratios	1	Symbology	Define the problem, the study area and the database. To easily map ratios (e.g. population density).
Describe and map variables. Calculate and map z-scores	2	Choropleth maps Histograms Basic statistics (Skewness, Kurtosis, etc.) Normal QQ plot Boxplots Z-score rendering	To locate areas of high or low income. To find if distributions are skewed. To identify if distributions follow the normal distribution. To identify outliers.
Conduct correlation and pairwise correlation analysis in the dataset variables	2	Scatter plots Scatter plot matrix	To identify if linear relationships exist among the variables. This will make modeling easier in a later step.
Where (explore)			
Analyze and measure the geographic distribution of crime events in the study area	3	Mean center Median center Standard distance Standard deviational ellipse	To find if directional or temporal trends in crime locations exist. This will help assessing better the optimal location of the coffee shop.
Point pattern analysis	3	Average nearest neighbor Ripley's *k*	To identify if the spatial pattern of crimes is random, dispersed or clustered. To find at which distance clustering or dispersion is more pronounced.
Create density maps	3	Kernel density estimation	To create a smooth map covering the study region depicting high or low densities in crime occurrences.
Locational outliers	3	Feature to point Near	Identify if locational outliers exist and remove them to calculate spatial statistics.
Identify if spatial autocorrelation of income exists	4	Spatial weights matrix Global Moran's *I* Incremental Spatial Autocorrelation Local Moran's *I* Getis-Ord G*	To conceptualize space by creating the spatial weights matrix. To identify if f high- or low-income values cluster in space. To locate hot or cold spots. To identify the scale of the analysis.

Identify if spatial autocorrelation of crime events exists	4	Optimized hot spot analysis	To identify in an optimized way if hot spots or cold spots of crime events exist. Hot spots of crime should be excluded from the potential locations for the coffee shop.
Multivariate data clustering	5	*k*-means clustering	Conduct geodemographical analysis based on a variety of socioeconomic variables.
Spatially constrained multivariate clustering	5	SCATTER	Spatial clustering (regionalization)
Similarity analysis	5	Similarity search (cosine similarity)	To identify similar postcodes to a target one as alternatively potential locations
Synthesis	5	Select by attributes/ location Export Reclassify	To identify the best location based on the evaluation criteria
How/Why (explain)			
Modeling relationships	6	Exploratory regression Ordinary least squares Geographically weighted regression	Model expenditures (independent) based on a set of dependent variables to identify the factors that increase expenditures
Modeling relationships	7	Spatial lag, spatial error, spatial regimes	Model expenditures (independent) based on a set of dependent variables utilizing spatial econometrics. Identify if expenditures are linked to spatial variables.

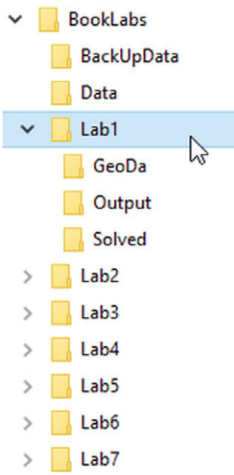


Figure 1.8 Dataset structure.

Dataset Structure

The structure of the datasets and related files under the folder `Booklabs` are as shown in Figure 1.8 (see also Box 1.5).

> **Box 1.5** Download Lab data from www.cambridge.org/9781108498982 and save them to `I:\BookLabs\` (you can save data to other location if you prefer like C:\).

`BackUpData` folder stores the original data and serves as the backup of the data stored in the folder `Data`. In case of corrupted, accidentally deleted or wrongly edited data, you should copy the dataset from the `BackUpData` folder and paste it into the `Data` folder. Each subsequent folder (e.g., Lab1) stores the `.mxd` files for each specific lab and the `Output` and `Solved` folders. The `Output` folder is used to save the output files of your analysis, like shapefiles, graphs, pdf or images. This is the main folder of your data analysis. The `Solved` folder provides the solved exercise (e.g., `Solved_Lab1_GettingToKnowDataSet.mxd`) along with the final dataset after any tools applied and editing. Use this folder to compare with your results. An additional folder, GeoDa, is used only in exercises solved with GeoDa software (see Section B).

The spatial data (stored into the `Data` folder) used in this book are described in Table 1.4.

Table 1.4 Spatial data.

Files	Depicting
City.shp	90 postcodes (polygons) consisting the case study area
Downtown.shp	Outer polygon of the downtown area of the city
Assaults.shp	Point events of assaults crime
Burglaries.shp	Point events of burglaries crime
Crime.shp	Point events of crime (both assaults and burglaries)

The attribute data of the City shapefile are described in Table 1.5.

Table 1.5 Socioeconomic data refer to the 2011 census (rescaling has been applied for confidentiality). These variables are the attribute fields of `City.shp`.

Attributes	Description
Population	Total population (persons)
Density	Population density (persons per square meter)
Foreigners	Population per cent (%) of foreigners (other than Greek nationality)
Owners	Population percentage (%) owing a house (not paying rent)
SecondaryE	Population percentage (%) obtained secondary education or less
University	Population percentage (%) with bachelor degree
PhD_Master	Population percentage (%) obtained master or higher degree
Income	Average annual income per capita in euros
Insurance	Average monthly insurance cost per capita (in euros)
Rent	Average monthly rent (in euros)
Expenses	Average monthly per capita expenses for daily purchases (in euros – i.e., grocery, coffee)
Area	Area of post code in square meters
Postcode	Five-digit unique ID

Table 1.6 Basic symbols used in explaining interaction with software.

Symbols	Meaning
>	Next action
TOC	Table of contents
RC	Right-click
DC	Double-click
TAB =	Select TAB
=	Set value

Guidelines

`This font and the term “ACTION:” indicate interactions with software. Folders, variables and file names will be also written in this font.`

The symbols used to explain actions are shown in Table 1.6.

Section A ArcGIS

Exercise 1.1 Getting to Know the Data and Study Region

This exercise describes how a population can be mapped and how population density can be calculated and rendered.

ArcGIS Tip: `All mxd files have been created using ArcGIS 10.4 version. If the previous version is installed, open an empty mxd file and insert the shapefiles of each exercise from the Data folder.`

Exercise 1.1 *(cont.)*

ArcGIS Tools to be used: Symbology, Zoom tools, Table of contents, Attribute table, Normalization

ACTION: Open dataset and map population

Navigate to the location you have stored the book dataset and double click Lab1_GettingToKnowDataSet.mxd

For example: I:\BookLabs\Lab1\Lab1_GettingToKnowDataSet.mxd

Tip: You can type this address directly to your windows explorer browser (just change the name of the drive-letter; if you have stored in C change I to C).

First, save the original file with a new name:

Main Menu > File > Save As > My_Lab1_GettingToKnowDataSet

In I:\BookLabs\Lab1\Output

TOC (Table of contents)> RC (Right-click) the City layer > Open Attribute Table (see Figure 1.9)

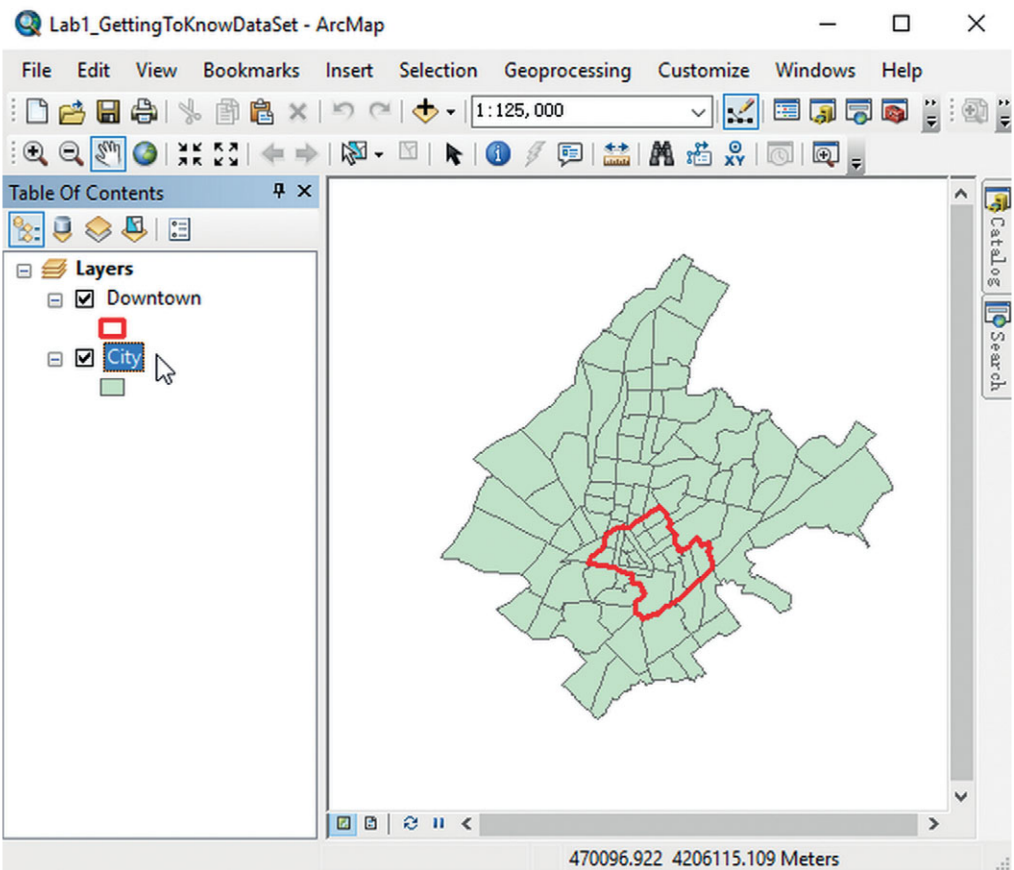
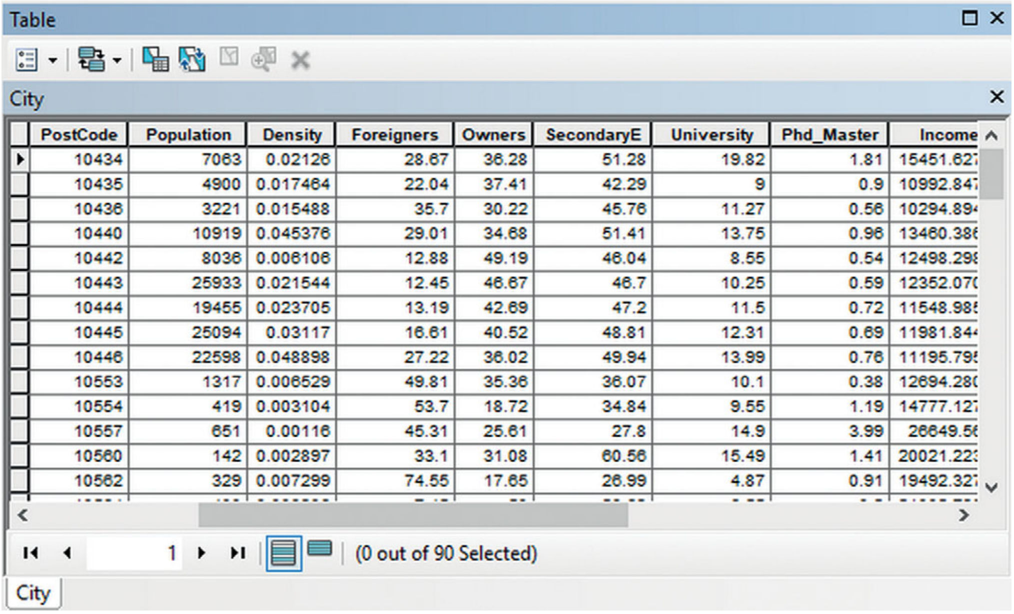


Figure 1.9 The case study area.

Exercise 1.1 (*cont.*)



PostCode	Population	Density	Foreigners	Owners	SecondaryE	University	Phd_Master	Income
10434	7063	0.02126	28.67	36.28	51.28	19.82	1.81	15451.62
10435	4900	0.017464	22.04	37.41	42.29	9	0.9	10992.84
10436	3221	0.015488	35.7	30.22	45.76	11.27	0.56	10294.89
10440	10919	0.045376	29.01	34.68	51.41	13.75	0.96	13460.38
10442	8036	0.006106	12.88	49.19	46.04	8.55	0.54	12498.29
10443	25933	0.021544	12.45	46.67	46.7	10.25	0.59	12352.07
10444	19455	0.023705	13.19	42.69	47.2	11.5	0.72	11548.98
10445	25094	0.03117	16.61	40.52	48.81	12.31	0.69	11981.84
10446	22598	0.048898	27.22	36.02	49.94	13.99	0.76	11195.79
10553	1317	0.006529	49.81	35.36	36.07	10.1	0.38	12694.28
10554	419	0.003104	53.7	18.72	34.84	9.55	1.19	14777.12
10557	651	0.00116	45.31	25.61	27.8	14.9	3.99	26649.5
10560	142	0.002897	33.1	31.08	60.56	15.49	1.41	20021.22
10562	329	0.007299	74.55	17.65	26.99	4.87	0.91	19492.32

Figure 1.10 A total of 90 postcodes with 17 fields are stored in the attribute table, of which 11 are socioeconomic variables (see Table 1.5).

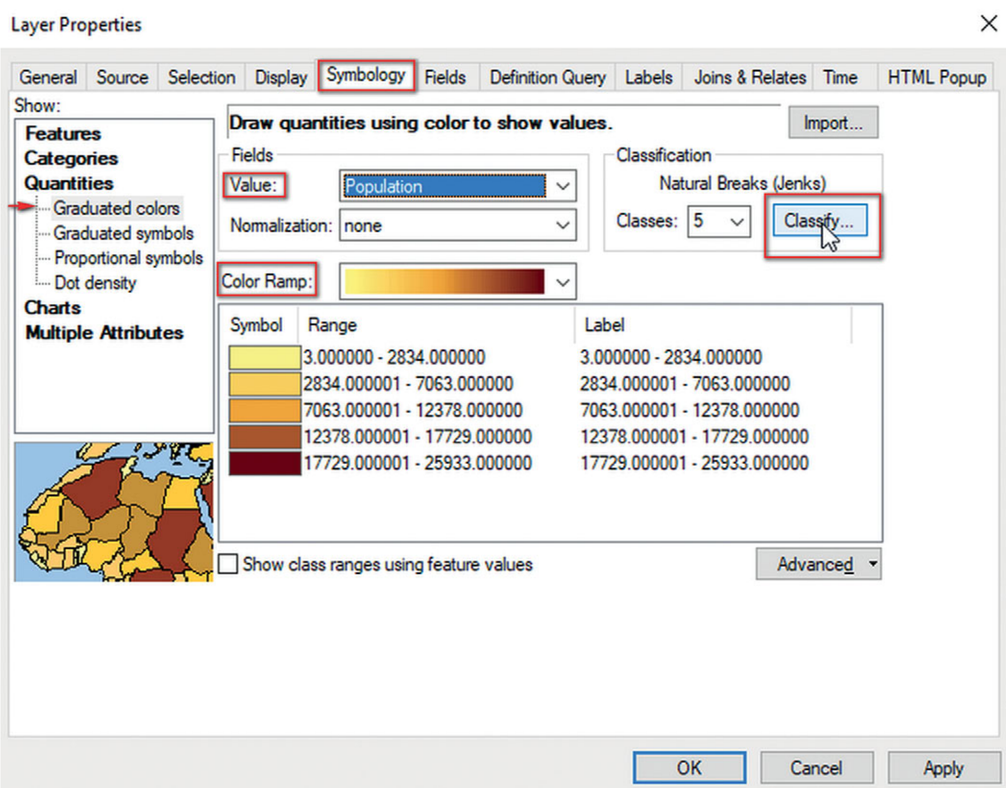


Figure 1.11 Layer properties dialog box for setting symbology.

Exercise 1.1 *(cont.)*

TOC > RC City > Properties > TAB = Symbology > Quantities > Graduated colors > Value = Population (see Figure 1.11)

Color Ramp = Yellow to Brown

Click Classify
Enter the following values in the Break Values window at the lower right (see Figure 1.12):

Break Values > 2000 > Enter > 5000 > Enter > 10000 > Enter > 15000 > Enter > 30000 > Enter > OK
RC Label > Format Labels > Select Numeric > Rounding > Number of decimal places = 2 > OK (see Figure 1.13)
Click Apply > OK

TOC > RC City > Save As Layer File > (see Figure 1.14)

Name = Population.lyr

In I:\BookLabs\Lab1\Output

Add the layer in the TOC.

Save

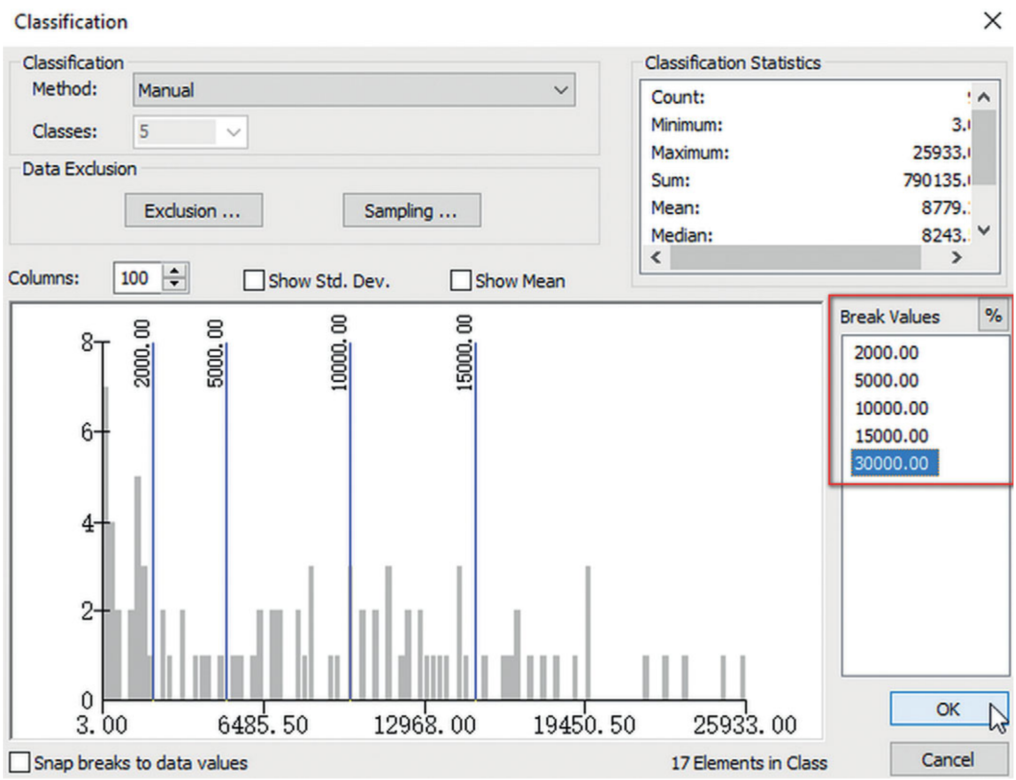


Figure 1.12 Setting categories range values.

Exercise 1.1 (*cont.*)

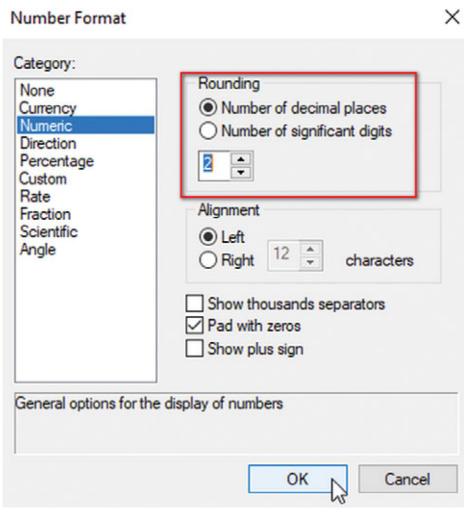


Figure 1.13 Defining number format.

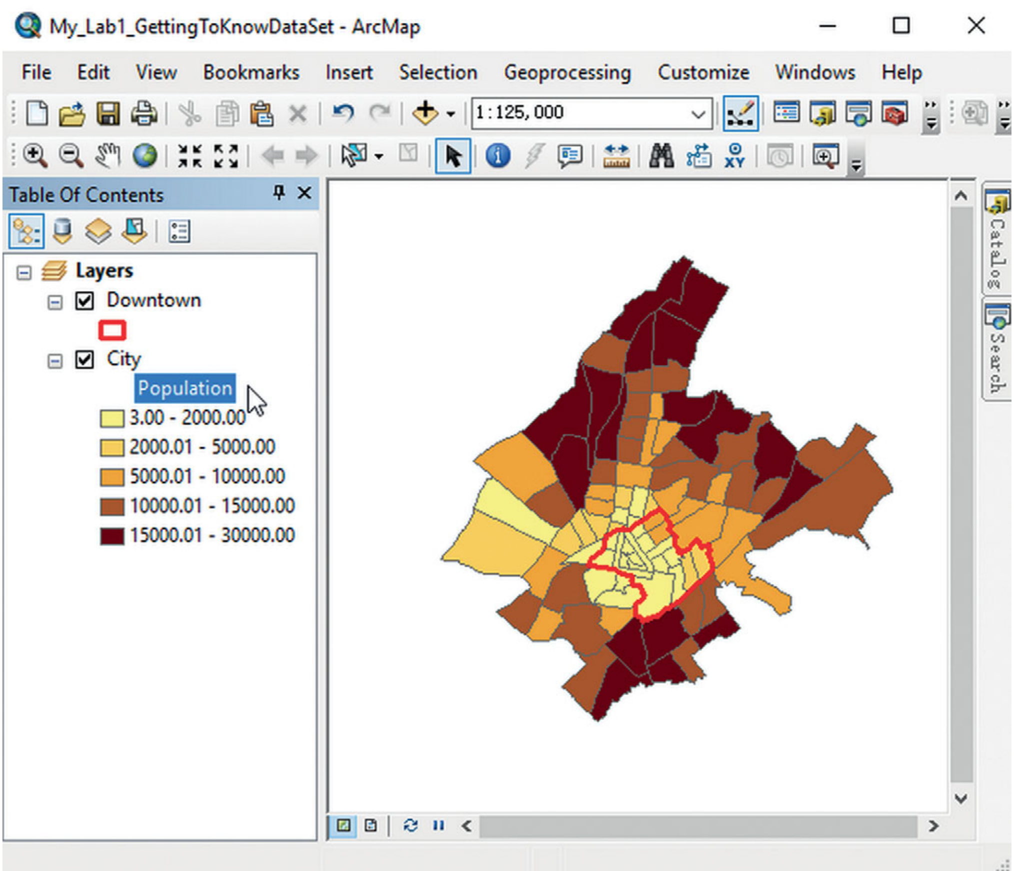


Figure 1.14 Population choropleth map.

Exercise 1.1 (*cont.*)

Interpreting results: The case study area is consisted of 90 postcodes (spatial features; see Figure 1.9). By opening the attribute table of City, we inspect the variables stored and the corresponding values for each spatial feature (see Figure 1.10). Postcodes in downtown have a lower population than the postcodes in the outskirts (see Figure 1.14). As the central postcodes are smaller in size, it is advised to additionally depict population density, as it provides a better mapping of population distribution within a study area.

ACTION: Calculate and map population density

RC the City layer (not the Population.lyr) > Properties > TAB = Symbology > Quantities > Graduated colors

Value = Population

Normalization = Area

Color Ramp = Light Green to Dark Green

Classes = 4

Click Classify > Break Values > 0.0100 > Enter > 0.0200 > Enter > 0.0300 > Enter 1.000 > OK

Density and break values refer to population per square meter. In practice, 0.01 means that 0.01 people live within 1m^2 or 1 person per 100m^2.

RC Label > Format Labels > Numeric > Number of decimal places = 2 > OK > Apply > OK

TOC > RC City > Save As Layer File >

Name = PopDensity.lyr

In I:\BookLabs\Lab1\Output

Add the layer in the TOC.

Main Menu > File > Save

Tip: Saving Population normalized by area into a layer file (.lyr) saves the density representation. When you add a layer in the table of contents, it is given the name of the original shapefile created (City in this example) and not the name it was saved (i.e., PopDensity.lyr; see Figure 1.15).

Interpreting results: Choropleth map of population density depicts smaller densities (for most postcodes) in the city center (downtown – red polygon)

Exercise 1.1 (*cont.*)

that grow larger as we move outward (see Figure 1.15). We locate a cluster of densely populated postcodes at the northern part of the city. On the other hand, population density is lower in downtown area probably because of its business and historic character (with fewer permanent residents). Similarities with the population map (see Figure 1.14) can be identified, but overall, population density map offers a better insight on how population is distributed across the postcodes. For example, in the downtown area, postcodes are described in more detail with population density compared to population.

ArcGIS tip: The normalization procedure in ArcGIS is used to divide one variable with another. This offers the ability to calculate rates of change (population increase), percentages (e.g., land cover share), per capita

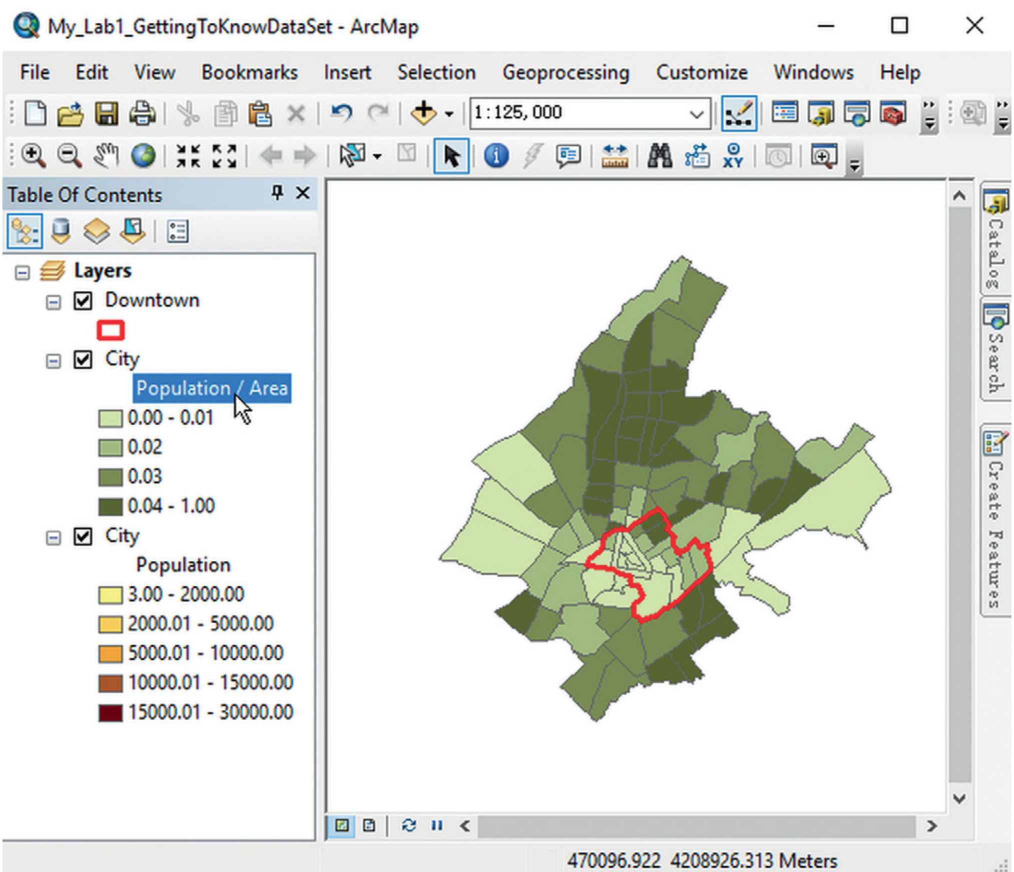


Figure 1.15 Population density.

Exercise 1.1 *(cont.)*

numbers (e.g., income per capita) and densities (e.g., population density). It should not be confused with the normalizing process that rescales data to a range [0,1] or [−1,1] (see Section 2.4). The normalization tool in ArcGIS is an adjustment that divides two variables. For example, if we have the aggregated income of all people living in each postcode, we can calculate and map the per capita income. A drawback of this tool is that we cannot obtain the values of the population density in a new field. We simply map the results. We can easily though produce this ratio using field calculator procedures. The normalization tool in ArcGIS is very useful when we need to test for various combinations of ratios. Once we decide which of the tested ratios to retain, we can calculate the values by using the field calculator.

Section B GeoDa

Box 1.6 Download and install GeoDa free and open-source software through http://geodacenter.github.io. Browse also the documentation section where you can find a detailed workbook. GeoDa is developed by Dr. Luc Anselin and his team and their contribution to the spatial analysis field is paramount.

Exercise 1.1 Getting to Know the Data and Study Region

This exercise describes how a population can be mapped and how population density can be calculated and rendered.

GeoDa Tools to be used: `Category editor`, `Zoom tools`, `Table`

`ACTION: Open dataset and map population`

`Navigate to the location you have stored the book dataset and click Lab1_GettingToKnowDataSet_GeoDa.gda inside the GeoDa folder`

`For example:`

`I:\BookLabs\Lab1\GeoDa\Lab1_GettingToKnowDataSet_GeoDa.gda`

Exercise 1.1 (*cont.*)

Tip: You can type this address directly to your windows explorer browser (just change the name of the drive letter; if you have stored in C, change I to C). Spatial data for GeoDa exercises are stored into GeoDa folder and not into Data folder. For spatial data and attribute values see Tables 1.4 and 1.5.

```
Main Menu > Click the Table icon (see Figures 1.16 and 1.17).
Click then on the Map-CityGeoDa window to activate it.
Main Menu > Map > Custom Breaks > Create New Custom Breaks >
(see Figure 1.18)
On the Variable Settings window (see Figure 1.19) select:

Population > OK
On the window 'New Custom Categories Title' type: Custom Breaks
(Population) and click OK
```

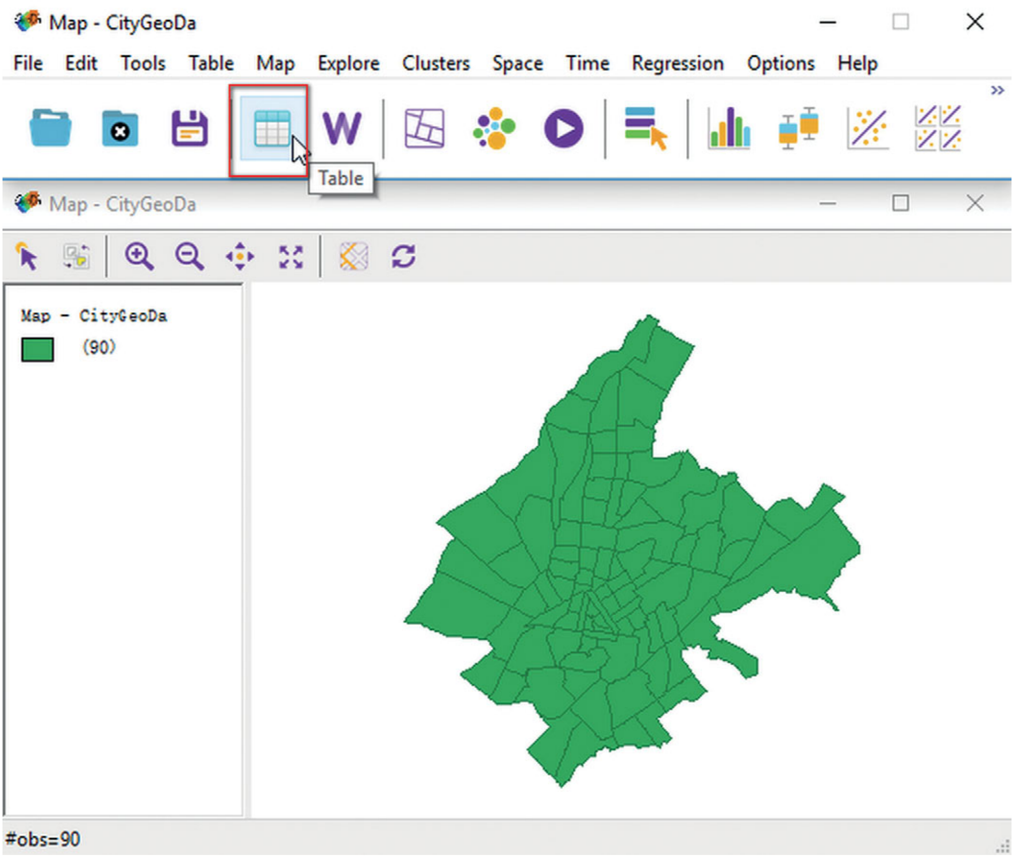


Figure 1.16 The case study area in GeoDa.

Table - CityGeoDa

	Municipali	PostCode	Population	SecondaryE	University	Phd_Master	Income	Insurance	Rent	Expenses	Area	Regimes	Density	Foreigners	Owners
1	ATHENS	10434	7063	51.280000	19.820000	1.810000	15451.630000	212.980000	632.040000	178.583919	332220.136904	2	0.020000	28.670000	36.280000
2	ATHENS	10435	4900	42.290000	9.000000	0.900000	10992.850000	118.410000	623.700000	79.890622	280581.940898	2	0.020000	22.040000	37.410000
3	ATHENS	10436	3221	45.760000	11.270000	0.560000	10294.890000	108.400000	624.930000	72.294562	207968.061788	2	0.020000	35.700000	30.220000
4	ATHENS	10440	10919	51.410000	13.750000	0.960000	13460.390000	116.000000	610.380000	98.658519	240635.086409	2	0.050000	29.010000	34.680000
5	ATHENS	10442	8036	46.040000	8.550000	0.540000	12498.300000	146.160000	492.590000	99.116531	1315988.950180	2	0.010000	12.880000	49.190000
6	ATHENS	10443	25933	46.700000	10.250000	0.590000	12352.070000	141.770000	480.810000	106.902080	1203704.016840	2	0.020000	12.450000	46.670000
7	ATHENS	10444	19455	47.200000	11.500000	0.720000	11548.990000	133.530000	577.480000	92.826920	820720.175172	2	0.020000	13.190000	42.690000
8	ATHENS	10445	25094	48.810000	12.310000	0.690000	11981.840000	138.630000	568.090000	108.358586	805075.936223	2	0.030000	16.610000	40.520000
9	ATHENS	10446	22598	49.940000	13.990000	0.760000	11195.800000	108.430000	608.680000	117.530858	462145.820779	2	0.050000	27.220000	36.020000
10	ATHENS	10553	1317	36.070000	10.100000	0.380000	12694.280000	157.320000	529.170000	64.621173	201720.185958	2	0.010000	49.810000	35.360000
11	ATHENS	10554	419	34.840000	9.550000	1.190000	14777.130000	304.580000	655.830000	178.809314	134969.727457	1	0.000000	53.700000	18.720000
12	ATHENS	10557	651	27.800000	14.900000	3.990000	26649.570000	445.730000	855.960000	442.114011	561343.171923	1	0.000000	45.310000	25.610000
13	ATHENS	10560	142	60.560000	15.490000	1.410000	20021.220000	462.310000	623.960000	195.567287	49023.275437	1	0.000000	33.100000	31.080000
14	ATHENS	10562	329	26.990000	4.870000	0.910000	19492.330000	441.640000	916.820000	164.762596	45076.450886	1	0.010000	74.550000	17.650000
15	ATHENS	10564	488	23.690000	6.550000	0.200000	21802.800000	404.940000	565.430000	176.925739	124950.154366	1	0.000000	7.450000	50.000000
16	ATHENS	10672	1406	34.780000	35.850000	11.380000	26202.090000	403.190000	777.740000	301.895511	122351.422990	1	0.010000	9.520000	39.000000
17	ATHENS	10682	1992	45.730000	26.810000	3.260000	22312.890000	365.600000	679.350000	318.759713	184924.421286	2	0.010000	19.300000	38.180000
18	ATHENS	11362	13511	50.480000	19.920000	2.050000	14097.120000	178.540000	600.270000	177.494529	298200.543540	2	0.050000	14.370000	40.050000
19	ATHENS	10683	2834	42.730000	27.200000	3.740000	17602.320000	236.930000	775.970000	200.488897	97401.934682	2	0.030000	11.970000	32.560000
20	ATHENS	11141	19642	47.990000	21.580000	1.850000	15545.310000	219.410000	607.030000	185.828585	843011.636198	2	0.020000	5.830000	44.750000
21	ATHENS	11142	18378	47.440000	14.860000	0.800000	14860.840000	204.280000	538.930000	134.450185	870428.122102	2	0.020000	8.330000	52.440000
22	ATHENS	10680	6433	41.430000	24.150000	4.070000	20829.760000	302.830000	641.110000	182.958107	148636.577176	1	0.040000	23.390000	30.900000
23	ATHENS	10681	6433	41.430000	24.150000	4.070000	17452.160000	245.370000	749.290000	178.264871	117805.016379	1	0.050000	23.390000	30.900000
24	ATHENS	11143	16526	49.070000	15.760000	1.010000	14385.850000	191.910000	587.420000	144.023649	939605.087959	2	0.020000	18.100000	46.000000

#row=90

Table - CityGeoDa

	PostCode	Population	SecondaryE	University	Phd_Master	Income
1	10434	7063	51.28	19.82	1.81	154
2	10435	4900	42.29	9.00	0.90	109
3	10436	3221	45.76	11.27	0.56	102
4	10440	10919	51.41	13.75	0.96	134
5	10442	8036	46.04	8.55	0.54	124
6	10443	25933	46.70	10.25	0.59	123
7	10444	19455	47.20	11.50	0.72	115
8	10445	25094	48.81	12.31	0.69	119
9	10446	22598	49.94	13.99	0.76	111

#row=90

Figure 1.17 A total of 90 postcodes with 15 fields are stored in the attribute table of which 11 are socioeconomic variables (see Table 1.5).

Exercise 1.1 (*cont.*)

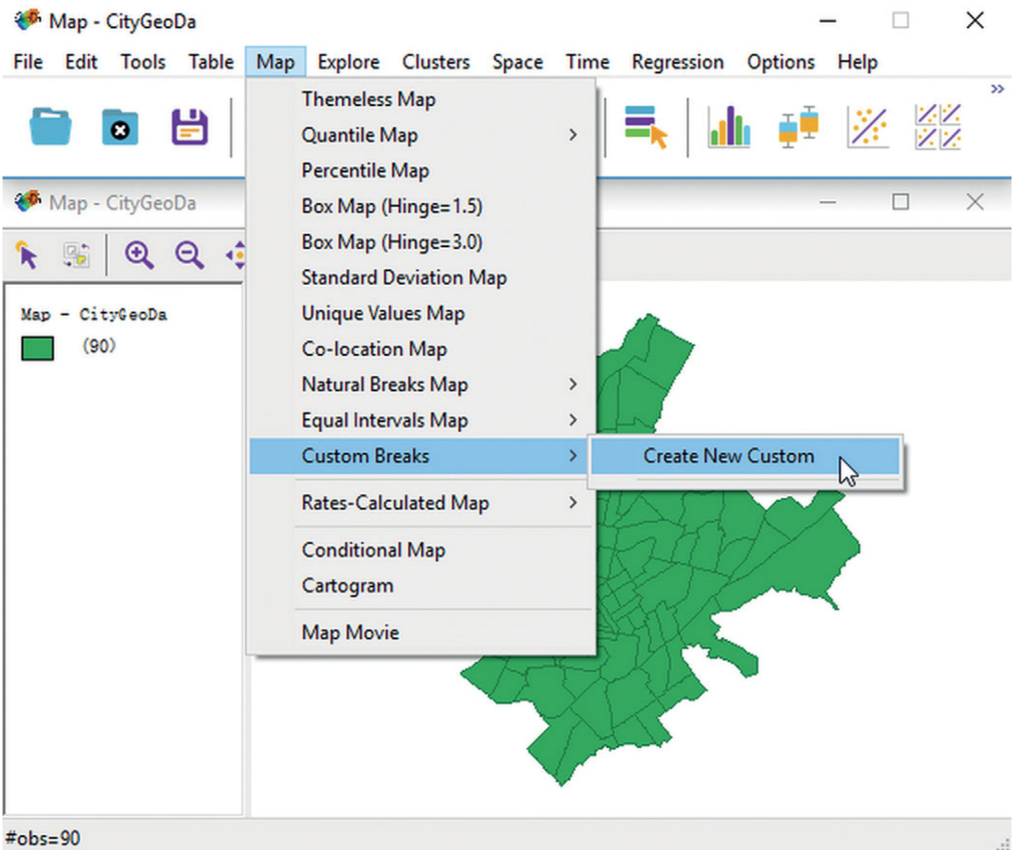


Figure 1.18 Creating a choropleth population map

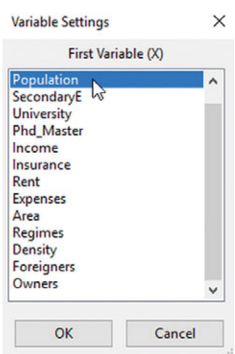


Figure 1.19 Variables selection dialog box.

Exercise 1.1 (*cont.*)

On the Category Editor, change only the following fields:Breaks = User Defined (see Figure 1.20)

Categories = 5

Type the following values directly in the break fields: break 1 = 2000 / break 2 = 5000 / break 3 = 10000 / break 4 = 15000 / break 5 = 20000 > Close the dialog box
The map is updated (see Figure 1.21)
Main Menu: Save

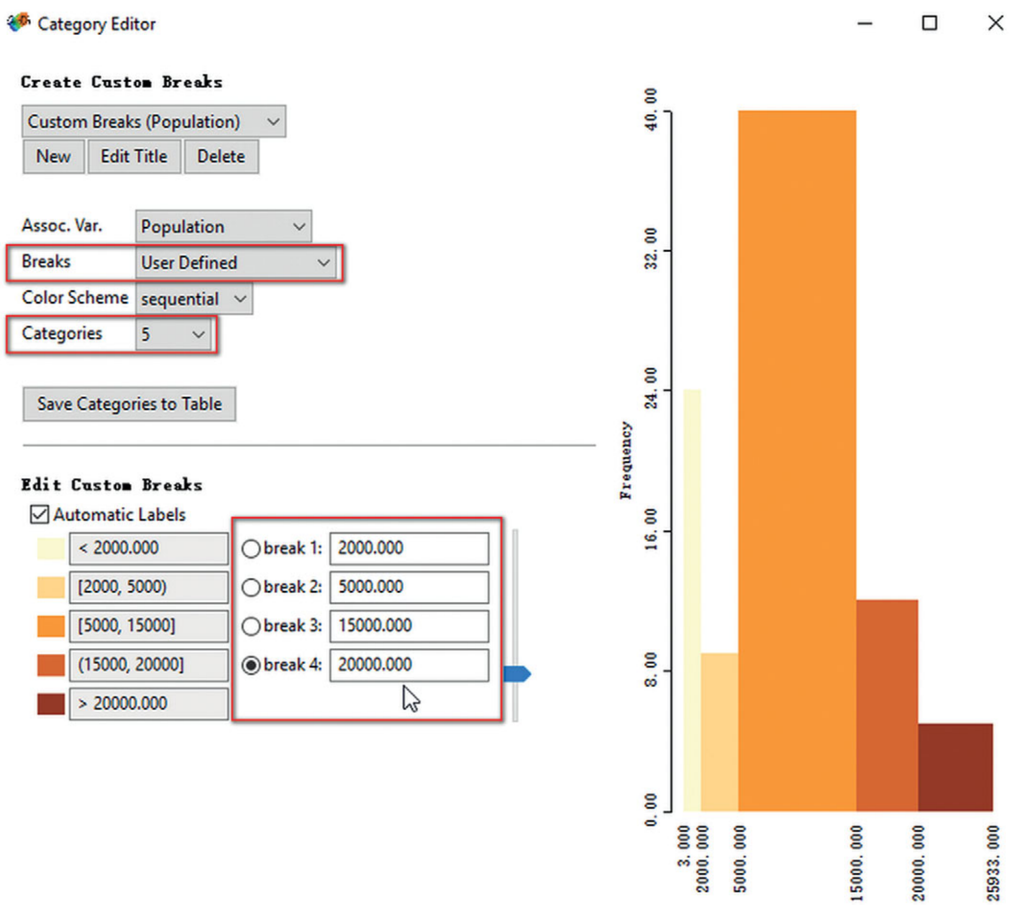


Figure 1.20 Category editor dialog box.

Exercise 1.1 *(cont.)*

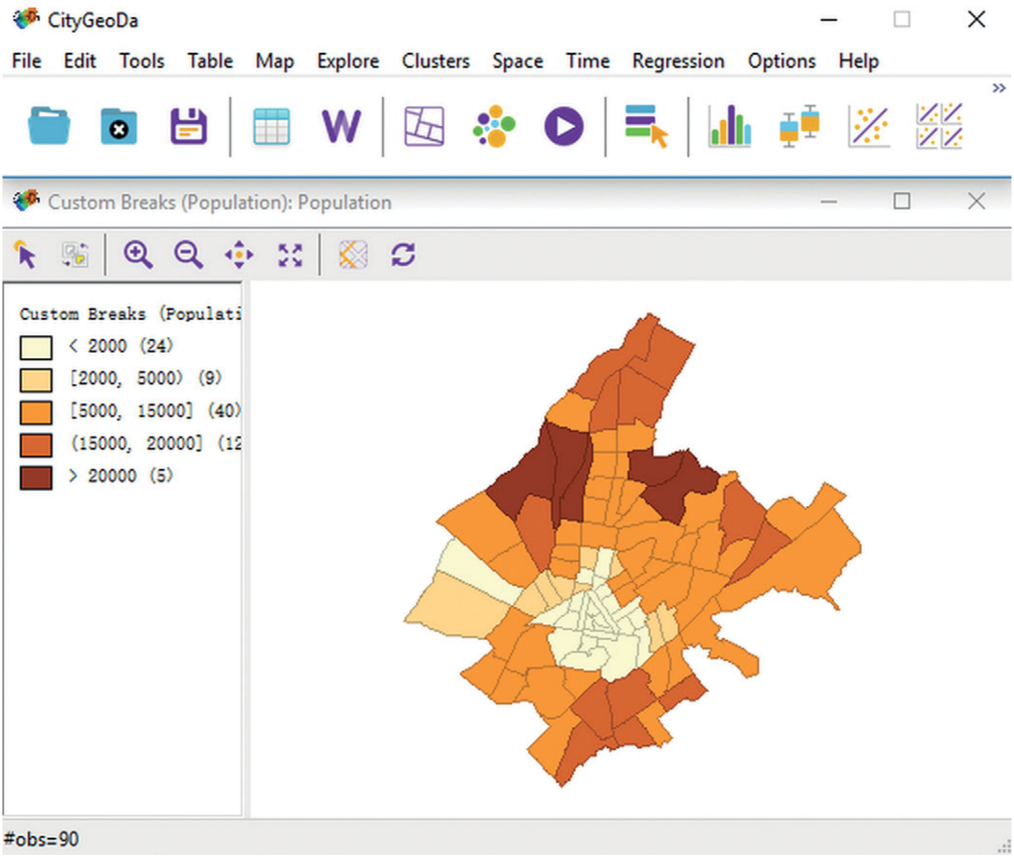


Figure 1.21 Population choropleth map.

Interpreting results: See Section A.

Tip: The interpretation of the results as well as the conclusions related to the analysis are not repeated here, as they are already presented in section A in the "Interpreting results" paragraphs of each exercise. The reader should study these sections carefully as they are independent of the software used.

ACTION: Calculate and map population density

Main Menu > Options > Rates > Raw Rate

Event Variable = Population (see Figure 1.22)

Base Variable = Area

Map Themes = Natural Breaks

Categories = 4 > OK (see Figure 1.23)

Save

Exercise 1.1 (*cont.*)

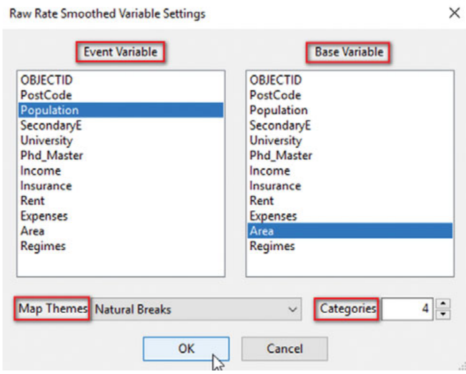


Figure 1.22 Setting the population density.

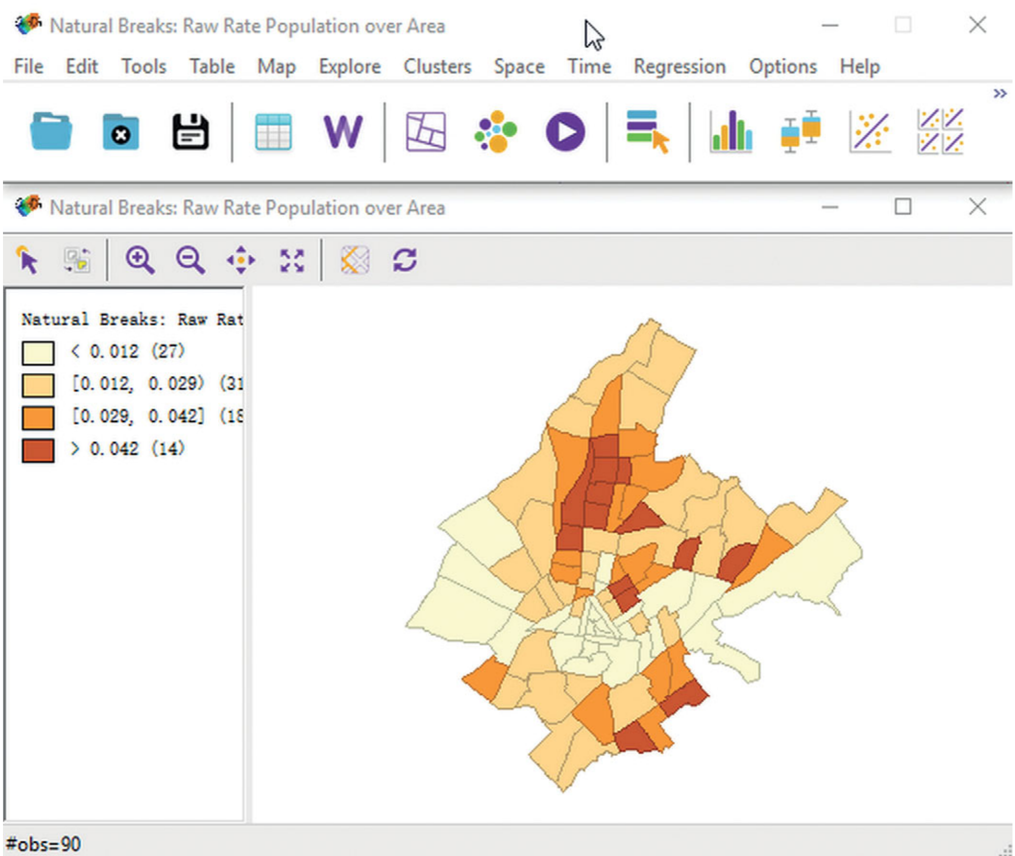


Figure 1.23 Population density map.

Interpreting results: See Section A.