Exercise Book 4

Covering the materials of Chapter 11.
Topics: vector spatial data management with geopandas

In the attached `data` folder the following attached datasets are given for this assignment:

- `hungary_admin_8.shp` , containing the city level administrative boundaries of Hungary. (Data source: *OpenStreetMap* (https://data2.openstreetmap.hu/hatarok/))
- `hungary_population_2020.csv` , containing the population of Hungarian cities on 2020 January 1. (Data source: *Hungarian Government* (https://www.nyilvantarto.hu/hu/statisztikak))
- `hungary_population_2011.csv` , containing the population of Hungarian cities on 2011 January 1. (Data source: *Hungarian Government* (https://www.nyilvantarto.hu/hu/statisztikak))

Note: in the CSV files the columns are delimited with `;` characters (instead of the default `,`).

Task 1

Write a program that creates a thematic map for Hungary based on the adminstrative boundaries of the cities and their population in 2020.
(Use the *All population* field from the CSV file.)

In [1]:

```
import pandas as pd
import geopandas as gpd

# Read the datasets
cities = gpd.read_file('../data/hungary_admin_8.shp')
cities = cities[['NAME', 'geometry']]
cities.set_index('NAME', inplace=True)

population_2020 = pd.read_csv('../data/hungary_population_2020.csv', delimiter =
 ';')
population_2020.set_index('City', inplace=True)
```

In [2]:

```
# Add the population DataSeries to the cities "manually"
df = cities.copy()
df['All population'] = [None] * len(cities)

# Get the indexes which are present in both DataFrames
indexes = set(cities.index) & set(population_2020.index)
for index in indexes:
    df.loc[index, 'All population'] = population_2020.loc[index]['All populatio
n']

display(df)
```

NAME	geometry	All population
Murakeresztúr	POLYGON ((1875811.200 5837364.810, 1875829.320...	1712
Tótszerdahely	POLYGON ((1865447.010 5842664.860, 1865626.780...	1081
Molnári	POLYGON ((1871422.780 5840886.420, 1871468.690...	689
Semjénháza	POLYGON ((1874690.000 5845206.400, 1874749.090...	566
Felsőszölnök	POLYGON ((1793789.650 5920727.330, 1793969.030...	578
...	...	...
Milota	POLYGON ((2530430.020 6120050.180, 2530441.900...	998
Tiszabecs	POLYGON ((2535824.870 6121698.150, 2535957.370...	1550
Garbolc	POLYGON ((2543379.140 6098625.170, 2543444.730...	150
Magosliget	POLYGON ((2540997.680 6116051.390, 2541064.470...	332
Beregdaróc	POLYGON ((2502185.370 6141427.990, 2502438.910...	1038

3174 rows × 2 columns

In [3]:

```
# This can be done in an easier and more efficient way with pandas' merge() func
tion
df = cities.merge(population_2020, left_index=True, right_index=True)
display(df)
```

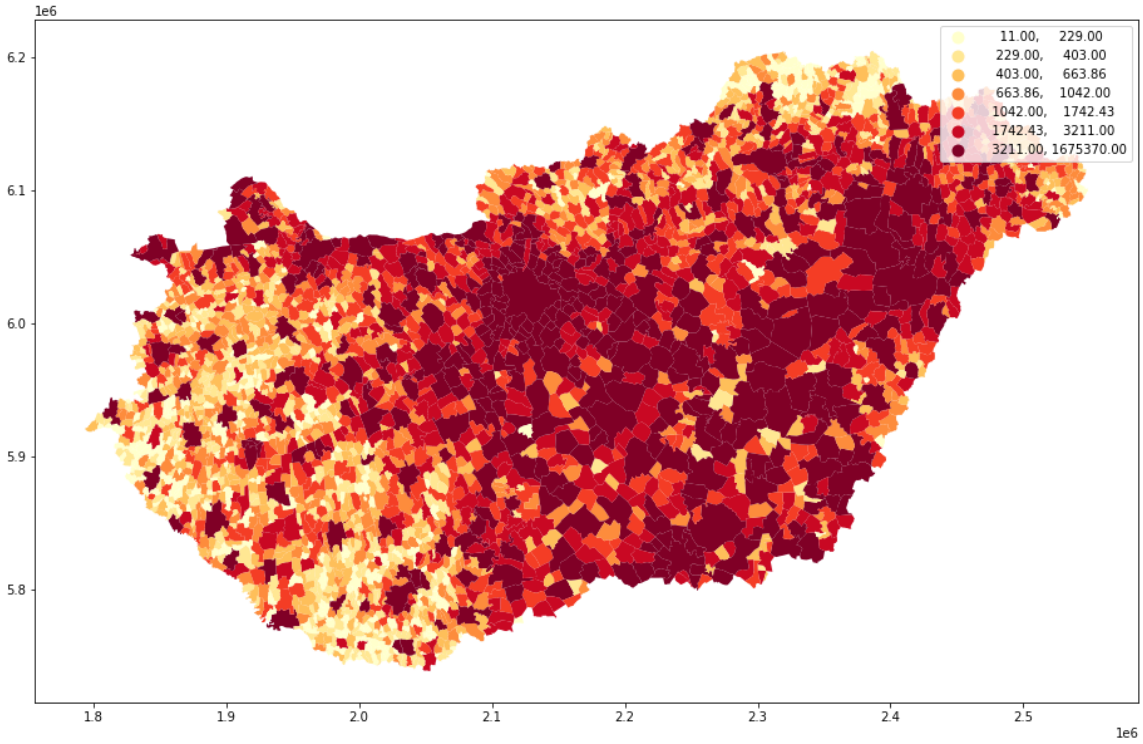
	geometry	County	Male population	Female population	All population
Aba	POLYGON ((2053298.230 5953037.810, 2053422.400...	FEJ	2286	2359	4645
Abaliget	POLYGON ((2010640.140 5804436.120, 2010699.370...	BAR	351	334	685
Abasár	POLYGON ((2223181.920 6072744.320, 2223372.480...	HEV	1168	1297	2465
Abaújalpár	POLYGON ((2362488.130 6156262.020, 2362552.180...	BOR	37	32	69
Abaújkér	POLYGON ((2354110.960 6161271.720, 2354200.650...	BOR	290	314	604
...	...	...	...	...	...
Őrimagyarósd	POLYGON ((1837790.790 5925016.100, 1837832.070...	VAS	117	113	230
Őriszentpéter	POLYGON ((1821634.850 5916224.320, 1821691.900...	VAS	568	589	1157
Őrtilos	POLYGON ((1878544.010 5830691.040, 1878570.100...	SOM	250	230	480
Ősagárd	POLYGON ((2132697.110 6082877.080, 2132823.710...	NOG	149	183	332
Ősi	POLYGON ((2020338.210 5965613.320, 2020523.530...	VES	1048	1027	2075

3174 rows × 5 columns

In [4]:

```
import matplotlib.pyplot as plt
%matplotlib inline

# Create the plot
df.plot(column='All population', figsize=[20,10], legend=True, cmap='YlOrRd', sc
heme='quantiles', k=7)
plt.show()
```



Task 2

Write a program that adds the population data for 2011 and 2020 to the Shapefile as new scalar fields to each city; and save it as a new Shapefile.

In [5]:

```
population_2011 = pd.read_csv('../data/hungary_population_2011.csv', delimiter =
 ';')
population_2011.set_index('City', inplace=True)

df = df.merge(population_2011, left_index=True, right_index=True, suffixes=[' 20
20', ' 2011'])
df.rename(columns={'County 2020':'County'}, inplace=True)
del df['County 2011']
display(df)
```

	geometry	County	Male population 2020	Female population 2020	All population 2020	Male population 2011	Fe popula
Aba	POLYGON ((2053298.230 5953037.810, 2053422.400...	FEJ	2286	2359	4645	2273	
Abaliget	POLYGON ((2010640.140 5804436.120, 2010699.370...	BAR	351	334	685	315	
Abasár	POLYGON ((2223181.920 6072744.320, 2223372.480...	HEV	1168	1297	2465	1191	
Abaújalpár	POLYGON ((2362488.130 6156262.020, 2362552.180...	BOR	37	32	69	46	
Abaújkér	POLYGON ((2354110.960 6161271.720, 2354200.650...	BOR	290	314	604	329	
...	...	...	...	...	...	...	
Őrimagyarósd	POLYGON ((1837790.790 5925016.100, 1837832.070...	VAS	117	113	230	114	
Őriszentpéter	POLYGON ((1821634.850 5916224.320, 1821691.900...	VAS	568	589	1157	571	
Őrtilos	POLYGON ((1878544.010 5830691.040, 1878570.100...	SOM	250	230	480	285	
Ősagárd	POLYGON ((2132697.110 6082877.080, 2132823.710...	NOG	149	183	332	148	
Ősi	POLYGON ((2020338.210 5965613.320, 2020523.530...	VES	1048	1027	2075	1086	

3173 rows × 8 columns

In [6]:

```
# Save it to file
df.to_file('hungary_population.shp')
```

```
<ipython-input-6-ac2d3a3b95d7>:2: UserWarning: Column names longer t
han 10 characters will be truncated when saved to ESRI Shapefile.
  df.to_file('hungary_population.shp')
```

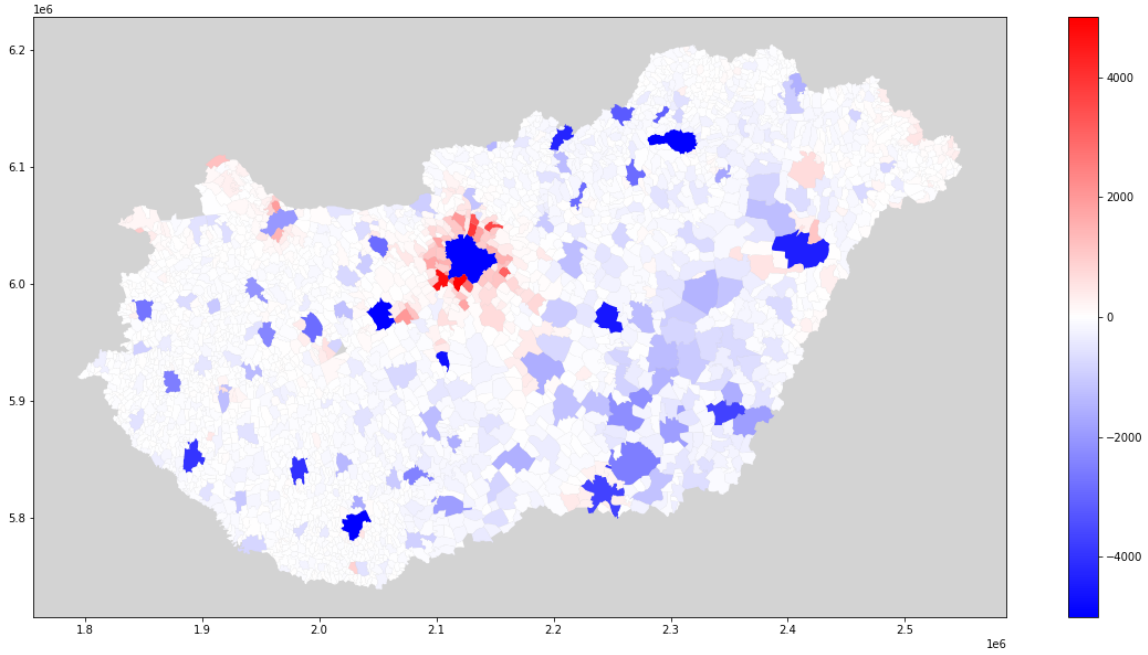
Task 3

Write a program that creates a thematic map for Hungary based on the adminstrative boundaries of the cities and their population change between 2011 and 2020.

In [7]:

```
df['Population difference'] = df['All population 2020'] - df['All population 201
1']

ax = df.plot(column='Population difference', figsize=[20,10], legend=True, cmap=
'bwr', vmin=-5000, vmax=5000)
ax.set_facecolor("lightgray") # background color
plt.show()
```



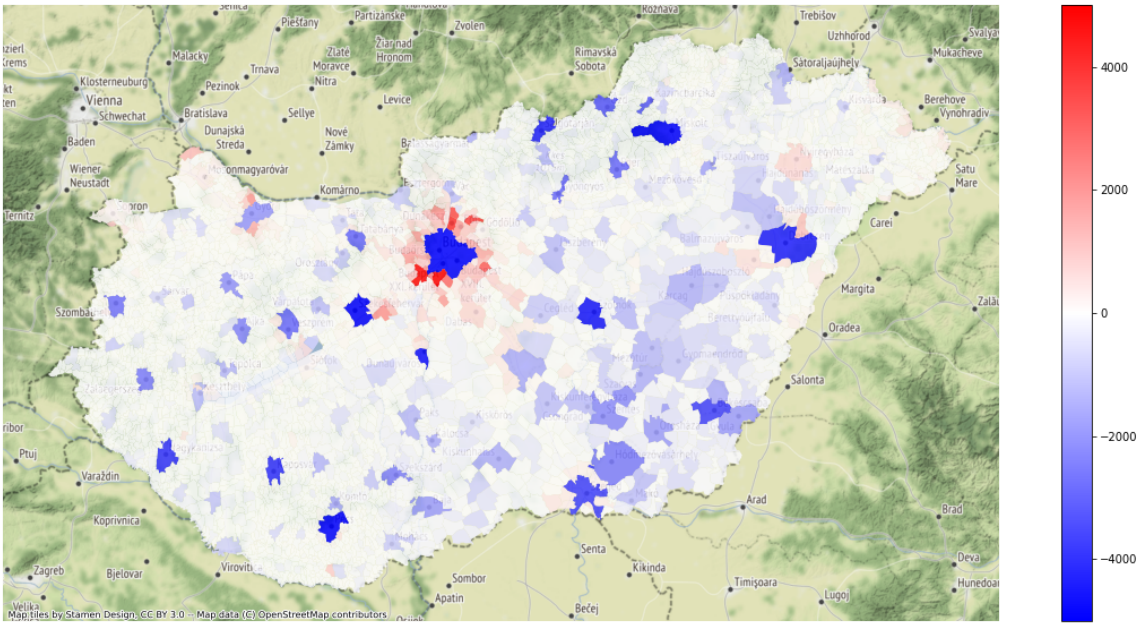
Optional: add a raster basemap with *contextily*.

In [8]:

```
# How to install: conda install -c conda-forge contextily
# How to use: https://contextily.readthedocs.io/en/latest/
import contextily as ctx

# Verify CRS, must be Web Mercator (EPSG:3857) to add a base map with the contex
tily module.
print(df.crs)
if df.crs == 'epsg:3857':
    ax = df.plot(column='Population difference', figsize=[20,10], legend=True, c
map='bwr', vmin=-5000, vmax=5000, alpha=0.85)
    ctx.add_basemap(ax)
    ax.set_axis_off()
    plt.show()
else:
    print('CRS must be EPSG:3857, instead {0} was given'.format(df.crs))
```

```
epsg:3857
```



Task 4

Write a program that creates a thematic map for Hungary based on the adminstrative boundaries of the cities and their population density in 2020.

In [9]:

```
df_eov = df.to_crs('EPSG:23700') # EOV is EPSG:23700
df['Area'] = df_eov.area / 10**6
df['Density 2020'] = df['All population 2020'] / df['Area']
display(df)
```

	geometry	County	Male population 2020	Female population 2020	All population 2020	Male population 2011	Fe popula
Aba	POLYGON ((2053298.230 5953037.810, 2053422.400...	FEJ	2286	2359	4645	2273	
Abaliget	POLYGON ((2010640.140 5804436.120, 2010699.370...	BAR	351	334	685	315	
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Abaújalpár	POLYGON ((2362488.130 6156262.020, 2362552.180...	BOR	37	32	69	46	
Abaújkér	POLYGON ((2354110.960 6161271.720, 2354200.650...	BOR	290	314	604	329	
...	...	...	...	...	...	...	
Őrimagyarósd	POLYGON ((1837790.790 5925016.100, 1837832.070...	VAS	117	113	230	114	
Őriszentpéter	POLYGON ((1821634.850 5916224.320, 1821691.900...	VAS	568	589	1157	571	
Őrtilos	POLYGON ((1878544.010 5830691.040, 1878570.100...	SOM	250	230	480	285	
Ősagárd	POLYGON ((2132697.110 6082877.080, 2132823.710...	NOG	149	183	332	148	
Ősi	POLYGON ((2020338.210 5965613.320, 2020523.530...	VES	1048	1027	2075	1086	

3173 rows × 11 columns

In [10]:

```
df.plot(column='Density 2020', figsize=[20,10], legend=True, cmap='YlOrRd', sche
me='quantiles', k=7)
plt.show()
```