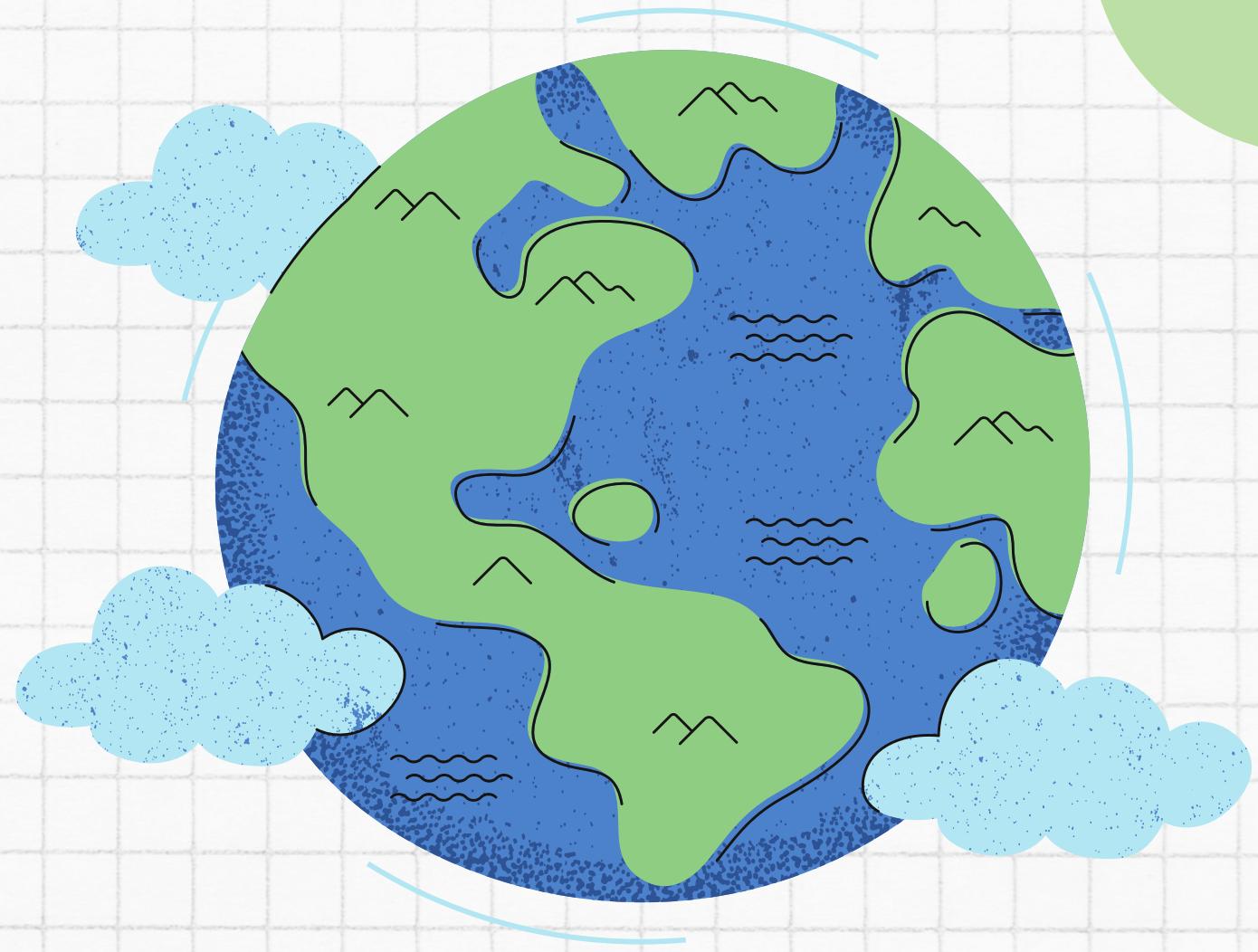


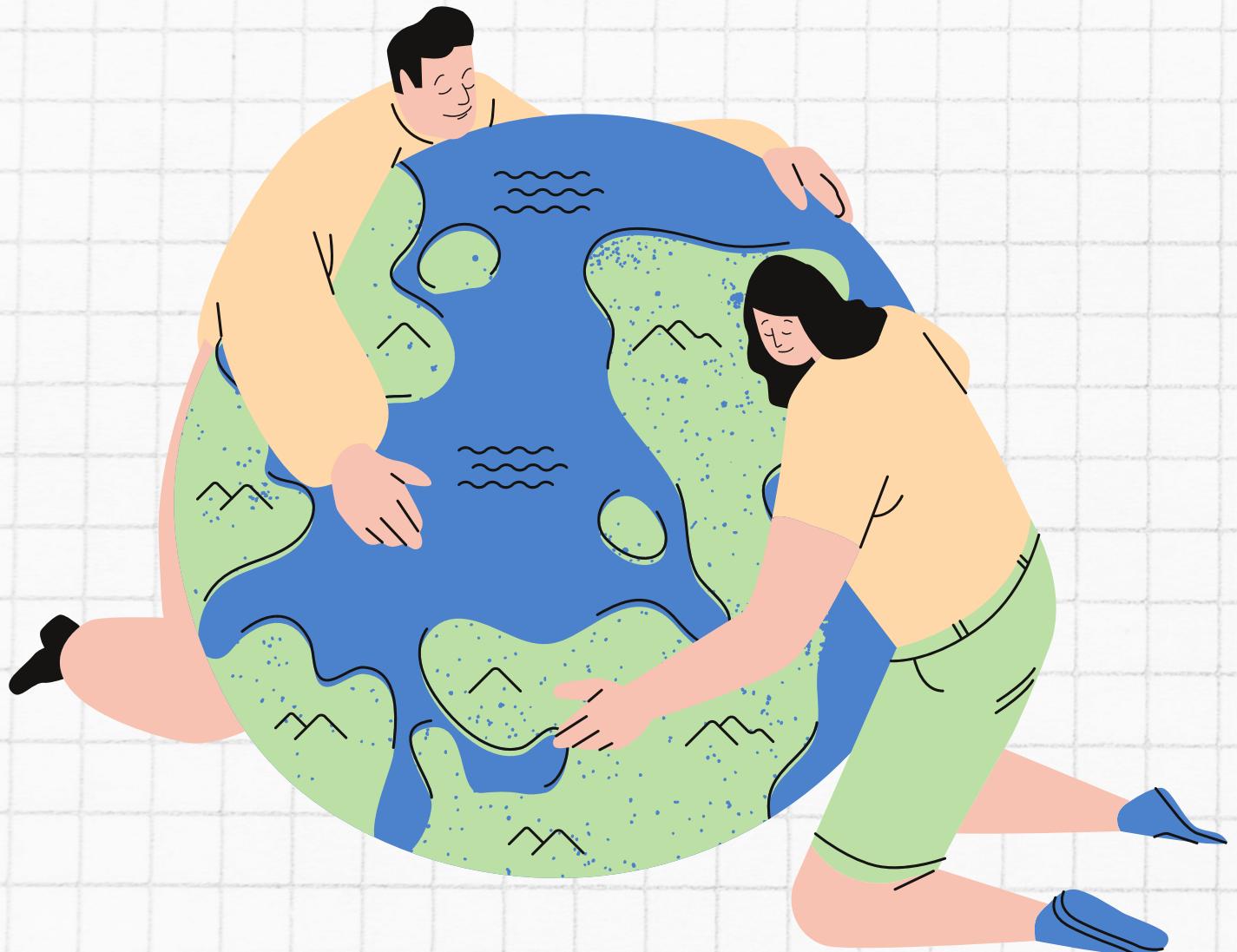
Waste generation and recycling

An overview in Europe

Presented by Mukami and Rand



Background



In our presentation, we delve into a decade of waste generation and recycling trends across European Union countries, with a specific focus on meeting the EU's recycling targets. The Packaging and Packaging Waste Directive mandates a 65% recycling target for packaging waste by December 31, 2025, escalating to 70% by December 31, 2030. These targets vary by material type, necessitating tailored strategies. Our analysis of the past decade's data aims to uncover patterns and challenges, providing insights to align practices with these ambitious recycling goals. Join us as we explore the current state of affairs in this industry.

Motivation

It has been reported by the European Environmental agency that

- 10 Member States are at risk of missing both the municipal waste (55%) and the total packaging waste (65%) recycling targets in 2025.
- Eight Member States are at risk of missing the municipal waste (55%) recycling target but on track to meet the total packaging waste target in 2025.
- Nine Member States (Austria, Belgium, Czechia, Denmark, Germany, Italy, Luxembourg, the Netherlands and Slovenia) are likely to meet the recycling targets for both municipal waste and total packaging waste, but only four of them are likely to also meet all material-specific packaging targets in 2025.
- 12 Member States are at risk of missing at least two material-specific packaging recycling targets in 2025.

We wanted to see if we could study the trends and hopefully identify the groups of countries listed above based on the data collected and displayed on the Eurostat Website.



**European
Environment
Agency**

Waste generation dataset

- Waste generation for all types of waste excluding major mineral waste.
- Information available for 38 countries
- In tones and kilogram per capita
- For periods of two years from 2004 to 2022
- Source: Eurostats
- includes all economic activities and in addition waste generated by households

Waste recycling dataset

- Waste recycling for all types of waste excluding major mineral waste.
- Information available for 32 countries
- In tones and kilogram per capita
- For periods of two years from 2004 to 2022
- Source: Eurostats
- all waste treated within the borders of a country (consequently excluding exports and including imports of waste).



Number of Recycling facilities

- Number of recycling facilities in european countries.
- Information available for 28 countries
- For periods of two years from 2010 to 2022
- Source: Eurostats

Questions

What are the geographical and time trends for waste generation, recycling, and number of recycling facilities in Europe? What is behind them?

What groups do the different countries cluster form based on waste generation and recycling? What are the similarities/differences in their trends?

Tools

Tableau:
To study the
geographical and time
trends.

Python:
Dataset exploration,
cleaning, clustering
analysis.



Which countries to include?

The three datasets covered different number of countries based on the definition of the european countries and the information available.

Only the countries that had information in the three datasets were kept (28). The information for the whole european union was excluded as well as we found irrelevant to our goals,

Data Cleaning

- Handling outliers: values that are more than 2 standard deviation away from the mean.

GEO (Labels)	2010	2012	2014	2016	2018	2020
Austria	1,162	1,109	1,142	1,157	1,634	1,642
Belgium	551	578	586	572	955	857
Bulgaria	593	610	626	752	752	752
Croatia	173	123	144	195	196	260
Cyprus	100	112	94	20	20	29
Czechia	1,511	1,669	1,389	2,250	2,578	170,684

The number of recycling facilities

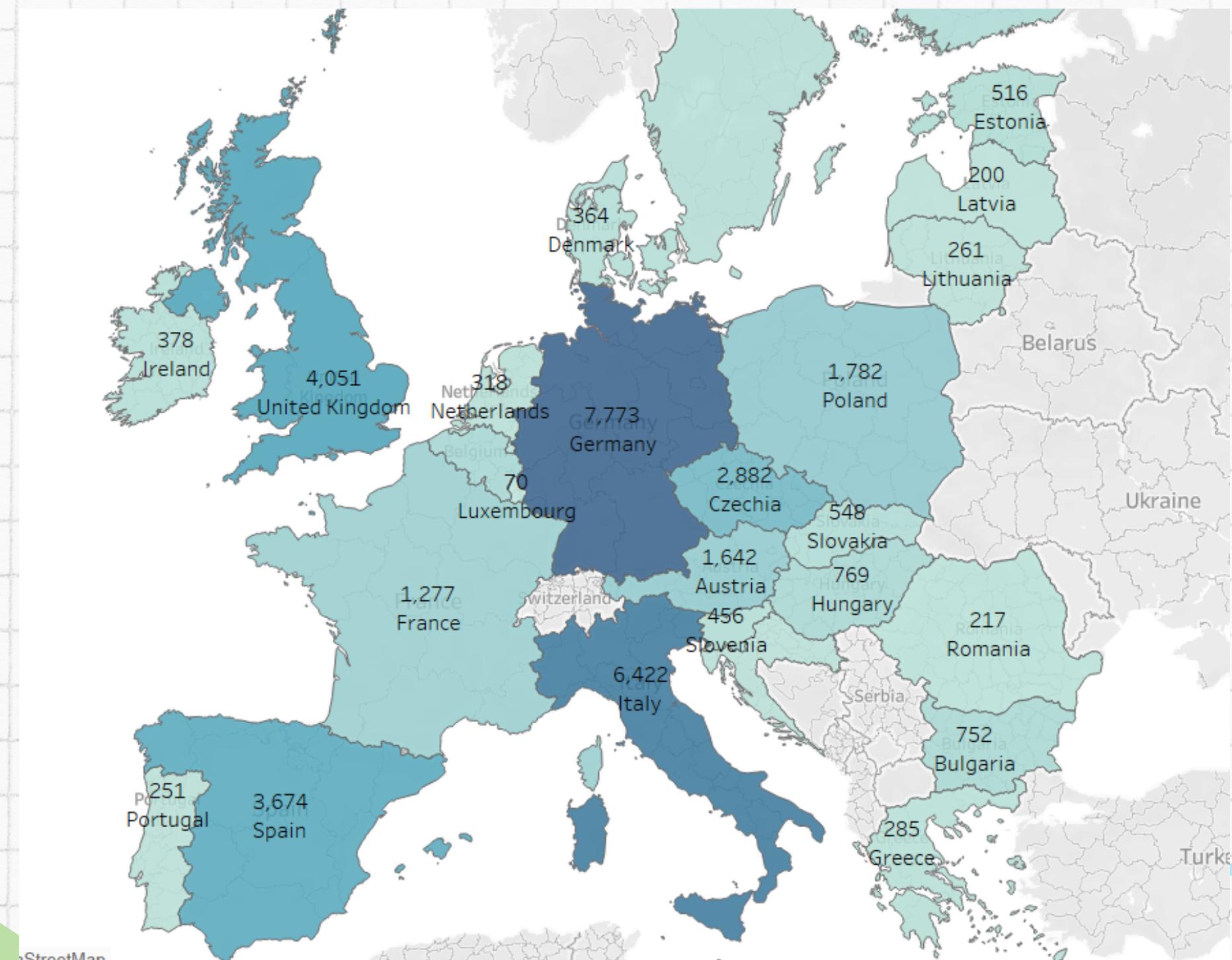
Data Cleaning

- 26 overall missing values + outliers
- Missing values: Predicted using imputing
- Multivariate feature imputation: models each feature with missing values as a function of other features, and uses that estimate for imputation.
- It takes into account similar rows (neighbors = 2)

Serbia	:	:	177	:	215	297
Slovakia		64	311	411	639	644
Slovenia		257	330	354	386	412
Spain		3,205	4,197	3,307	3,485	3,741
Sweden		7	14	359	462	436
United Kingdom		18,853	2,537	2,660	2,700	2,780 :

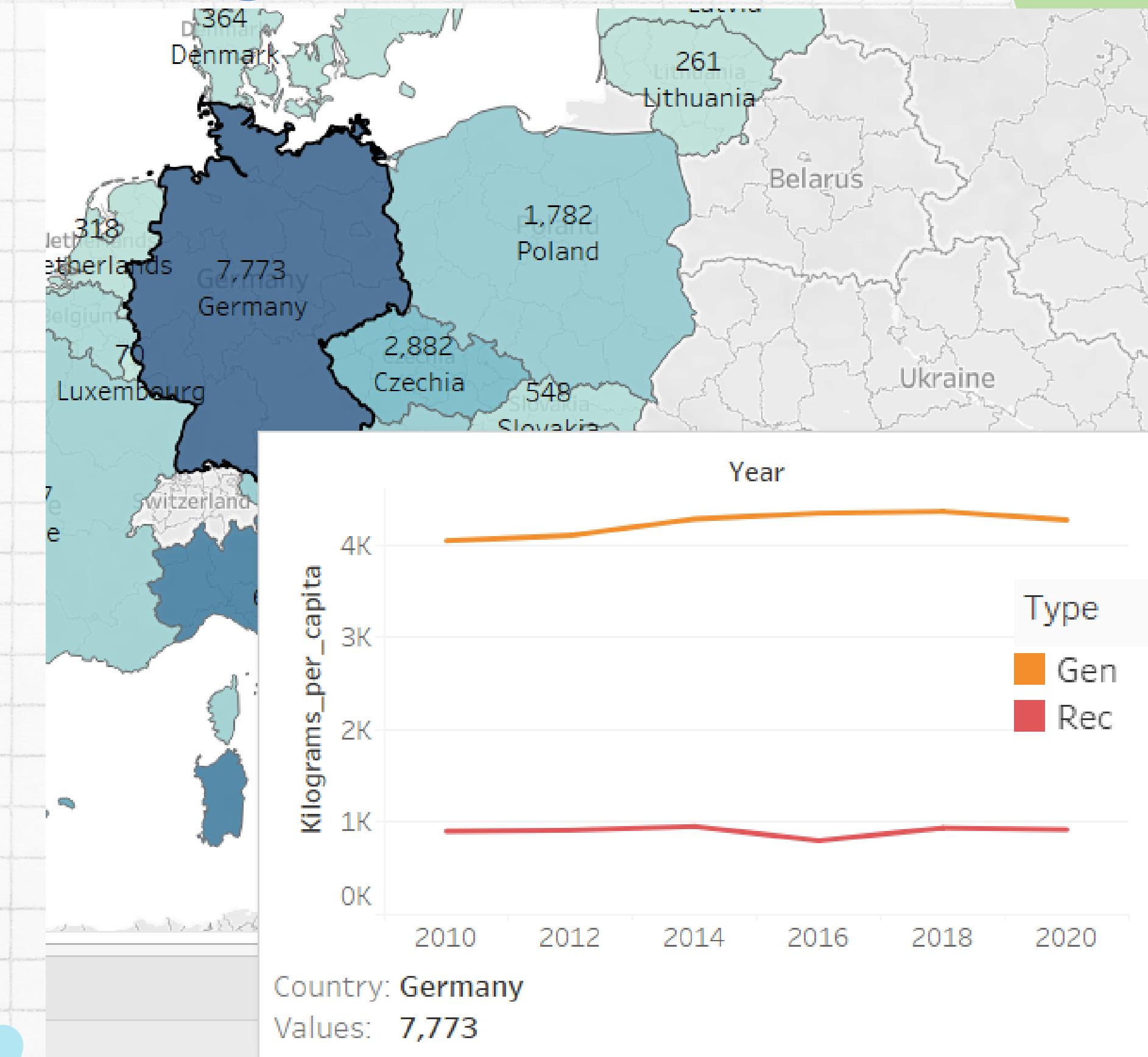
The number of recycling facilities

Number of recycling facilities in 2020



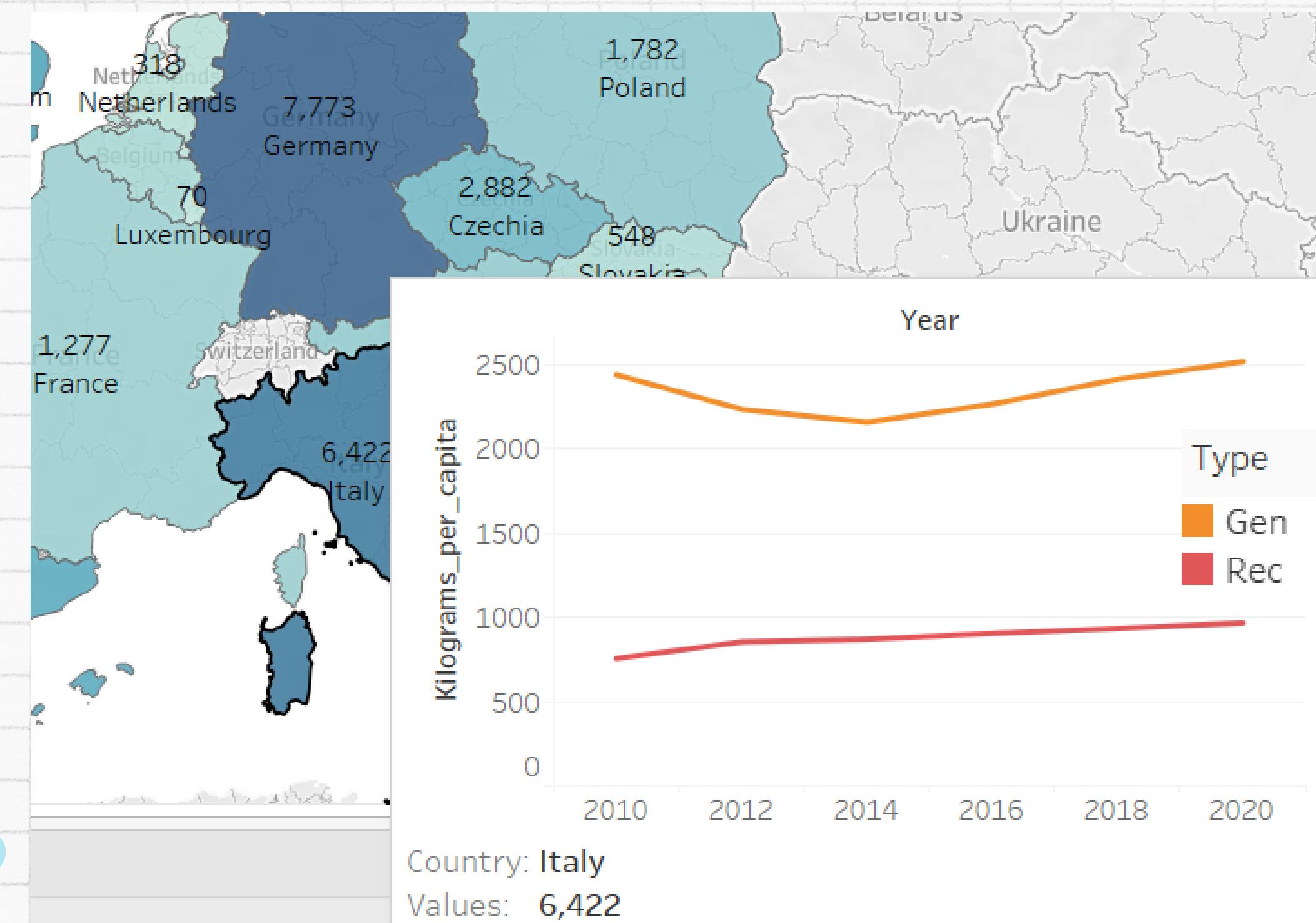
Germany

- Steady rate for generation and recycling over the year although several policies to reduce waste were implemented throughout the year.
- Export a lot of waste, especially to China before the ban in 2019.



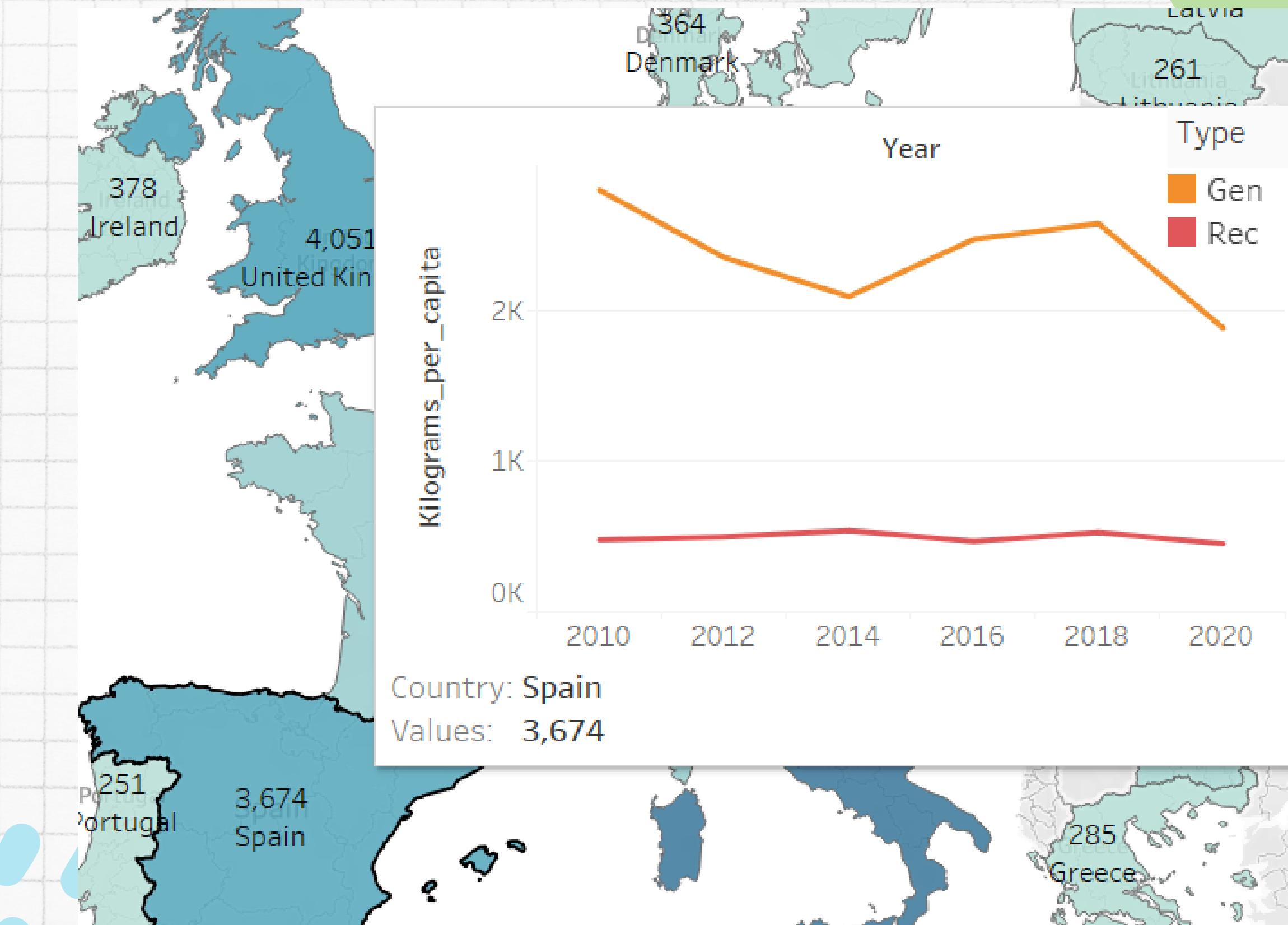
Italy

- The first waste prevention program (WPP) in Italy came into force in 2013, and waste generation dropped in the following year but increased in the years that followed.



Spain

- Waste generation was decreasing and reached its lowest point at 2014, which is linked to the global financial crisis.
- There was a decrease in GDP in the last few years, it reached in 2020 the same level as 2012.



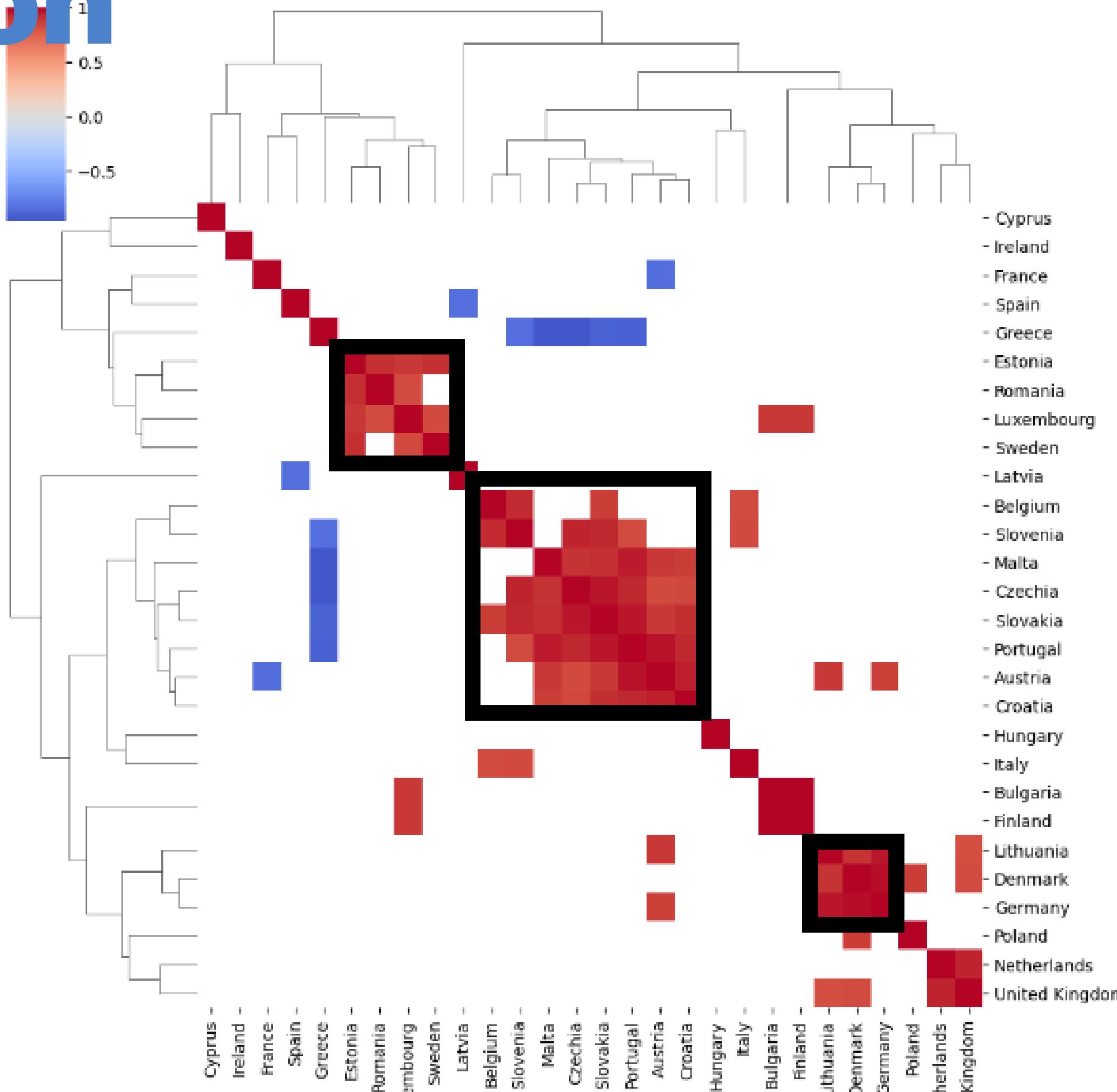
Clustering

1- based on correlation
using clustered
heatmaps

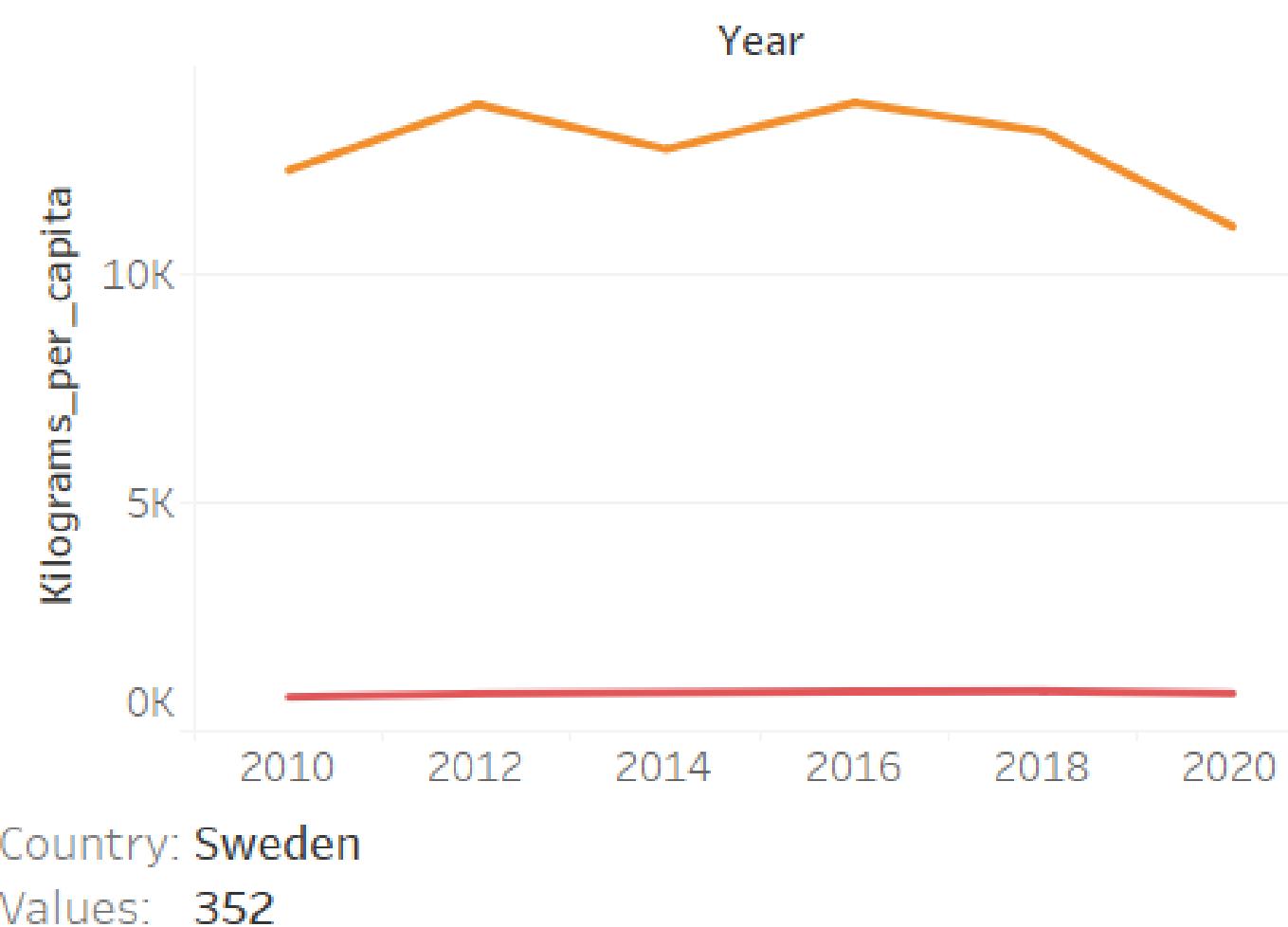
2- unsupervised using
knn algorithm

Waste generation

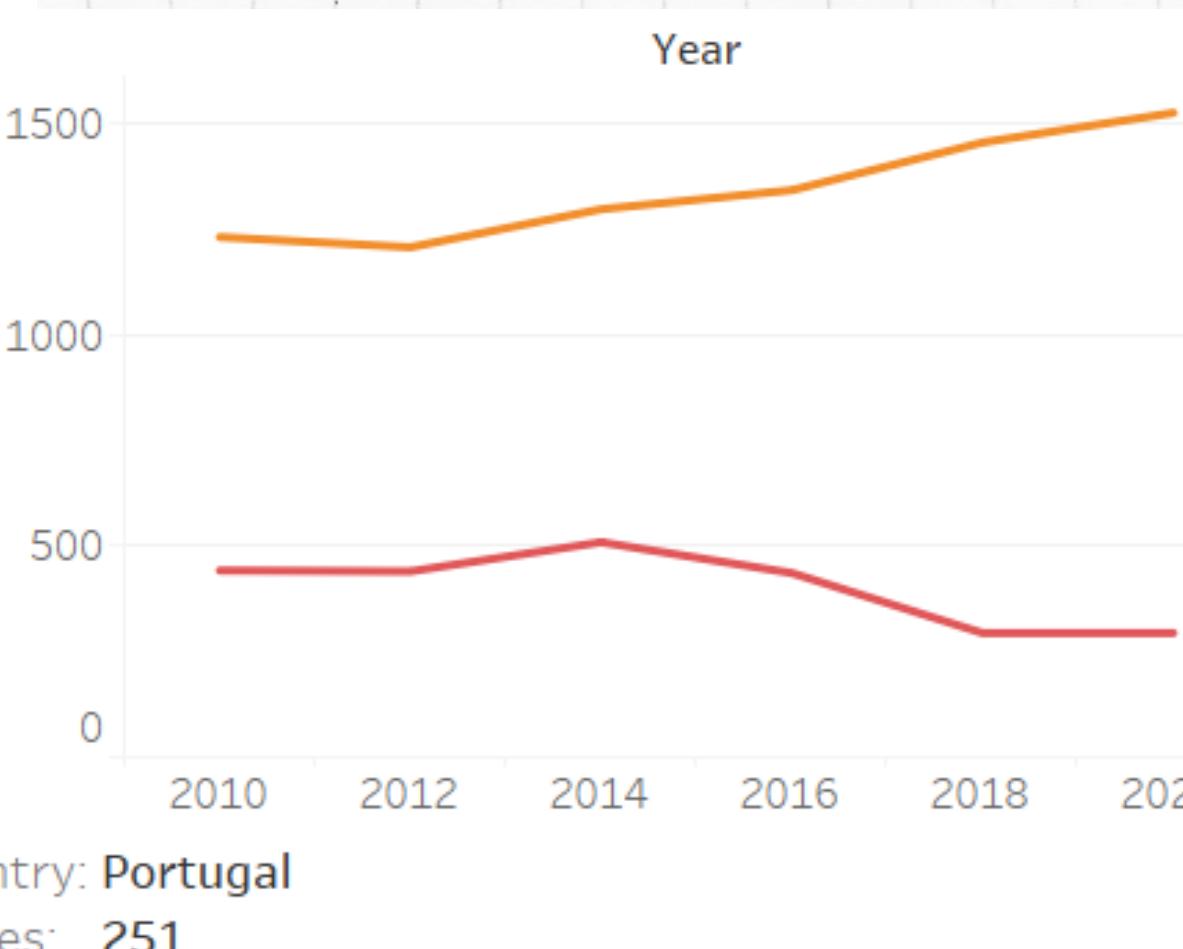
- Cluster 1: alternating periods of increase and decrease in waste generation.
- Cluster 2: A steady high increase in waste generation over the years.
- Cluster 3: increase in waste generation from 2010-2018 and then slight decrease.



Clusters examples



Cluster 1



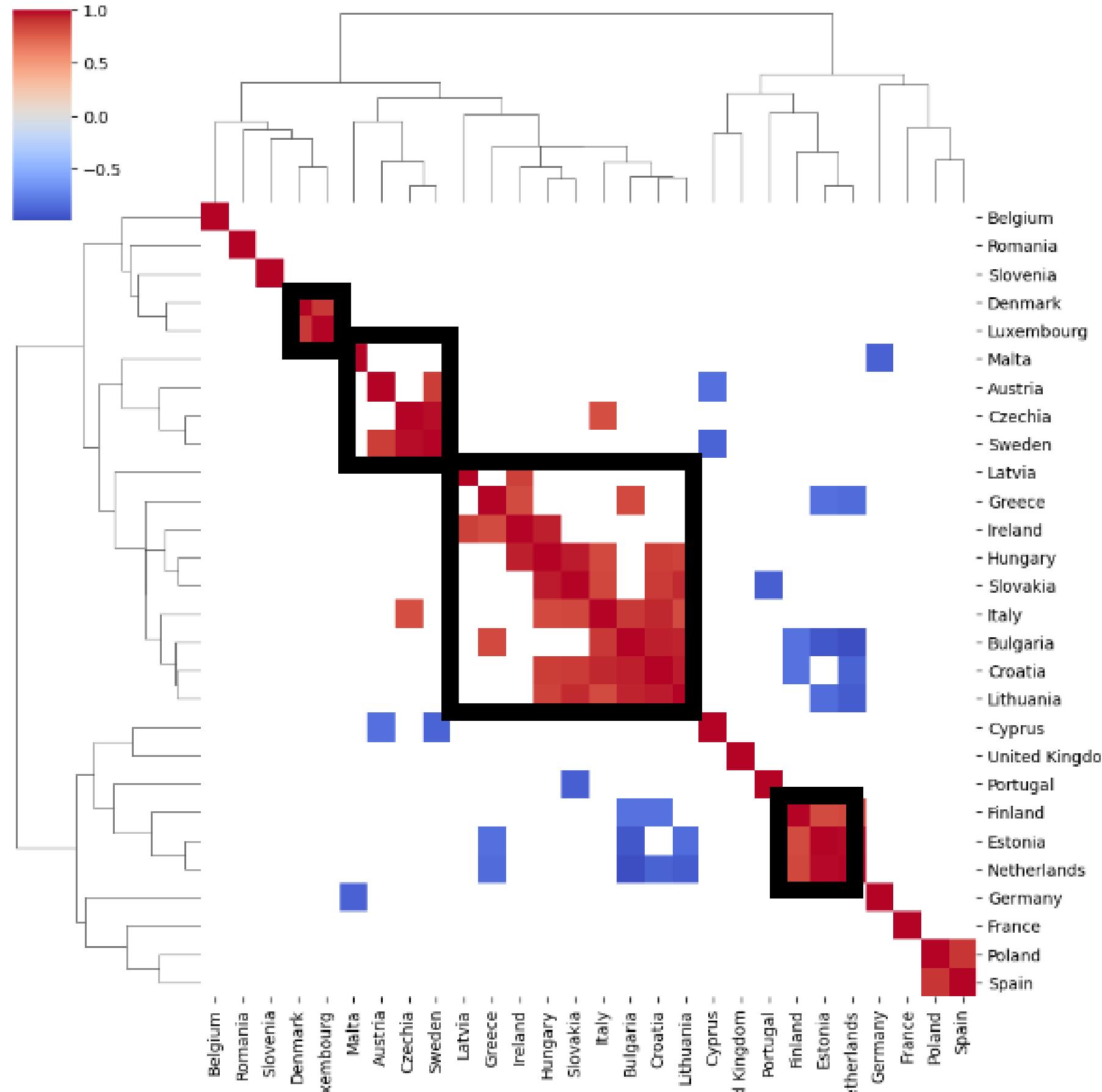
Cluster 2



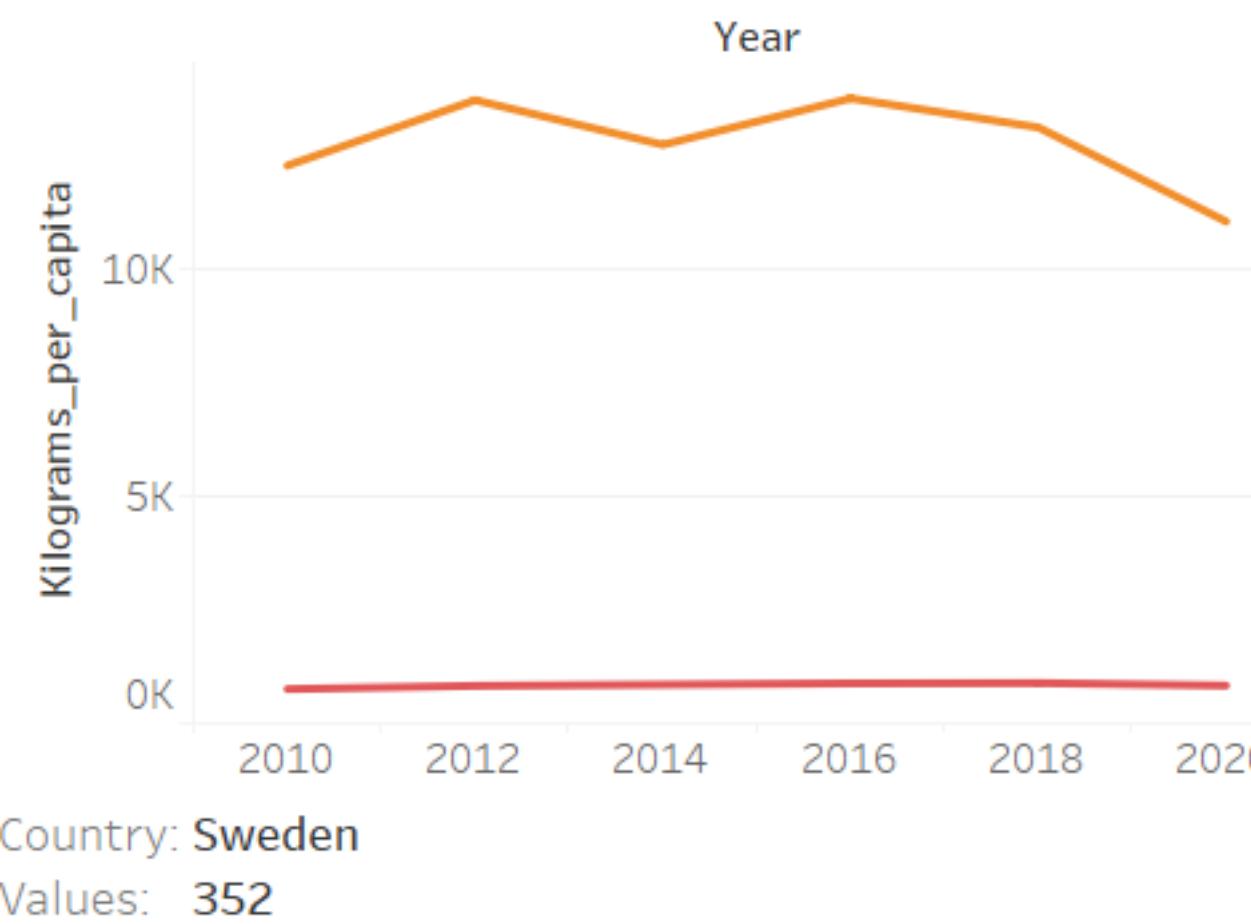
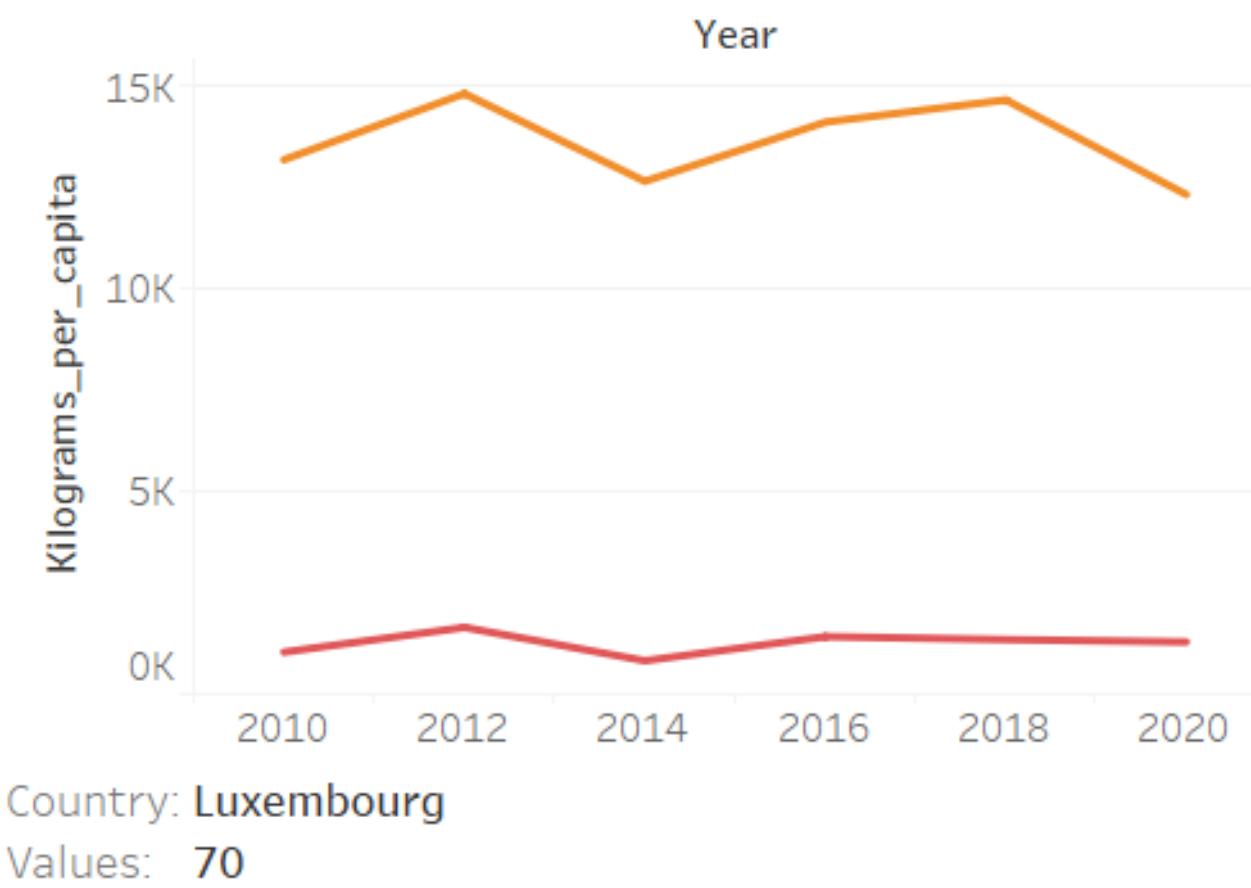
Cluster 3

Waste recycling

- Cluster 1: steady recycling rate with a small drop at 2014.
- Cluster 2: steady recycling rate.
- Cluster 3: increase in waste recycling over the time period.
- Cluster 4: steady recycling with a slight drop at 2016.

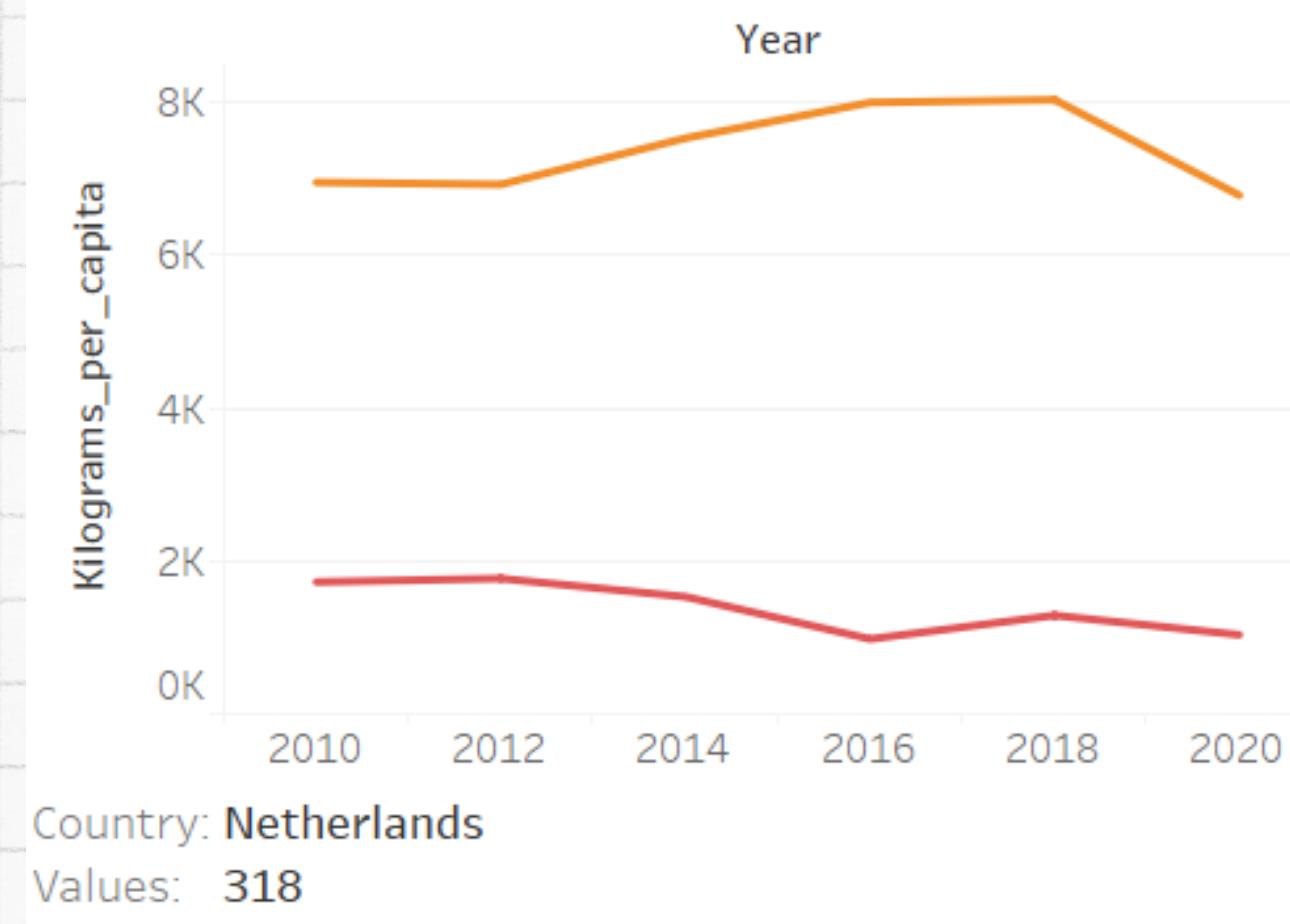
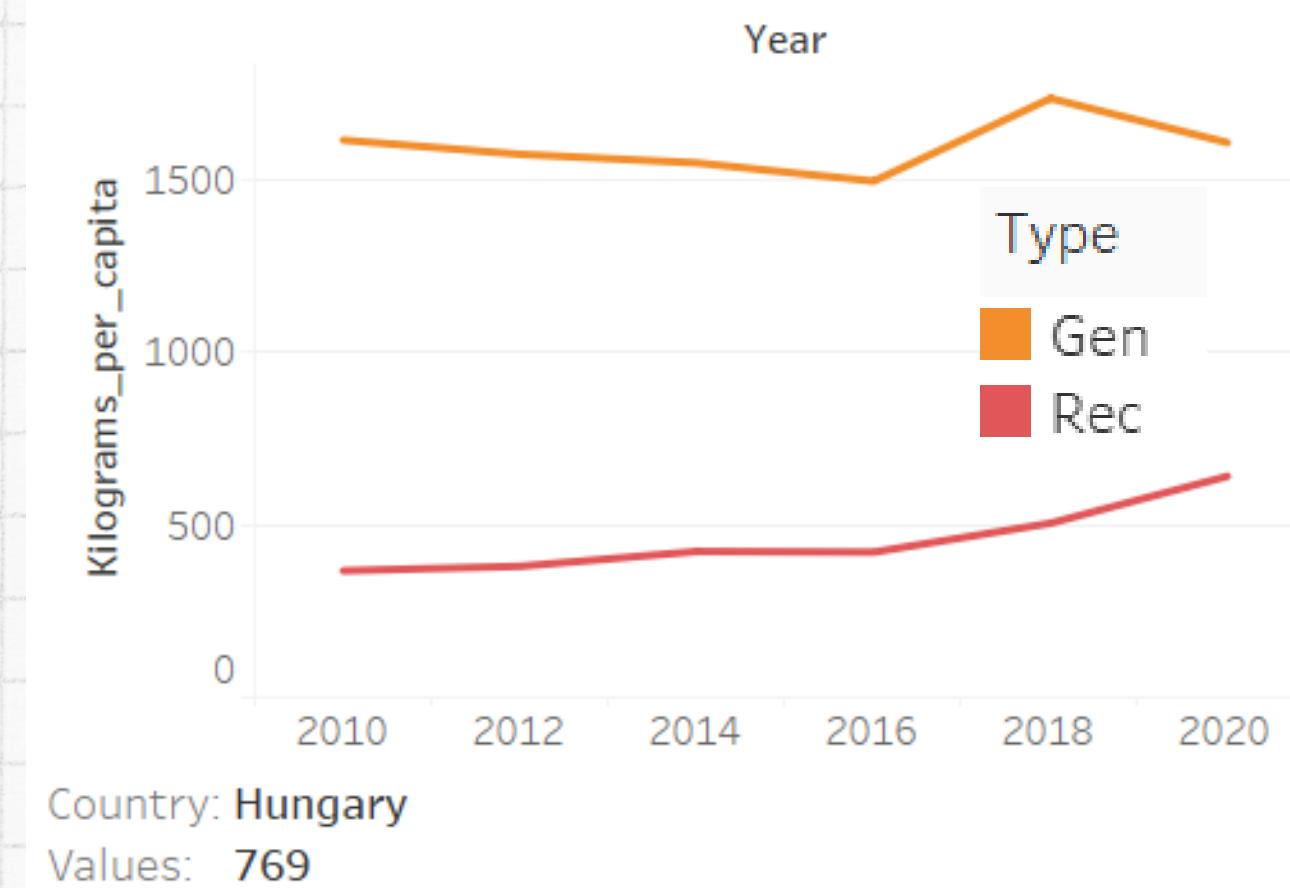


Clusters examples



Cluster 1

Cluster 2

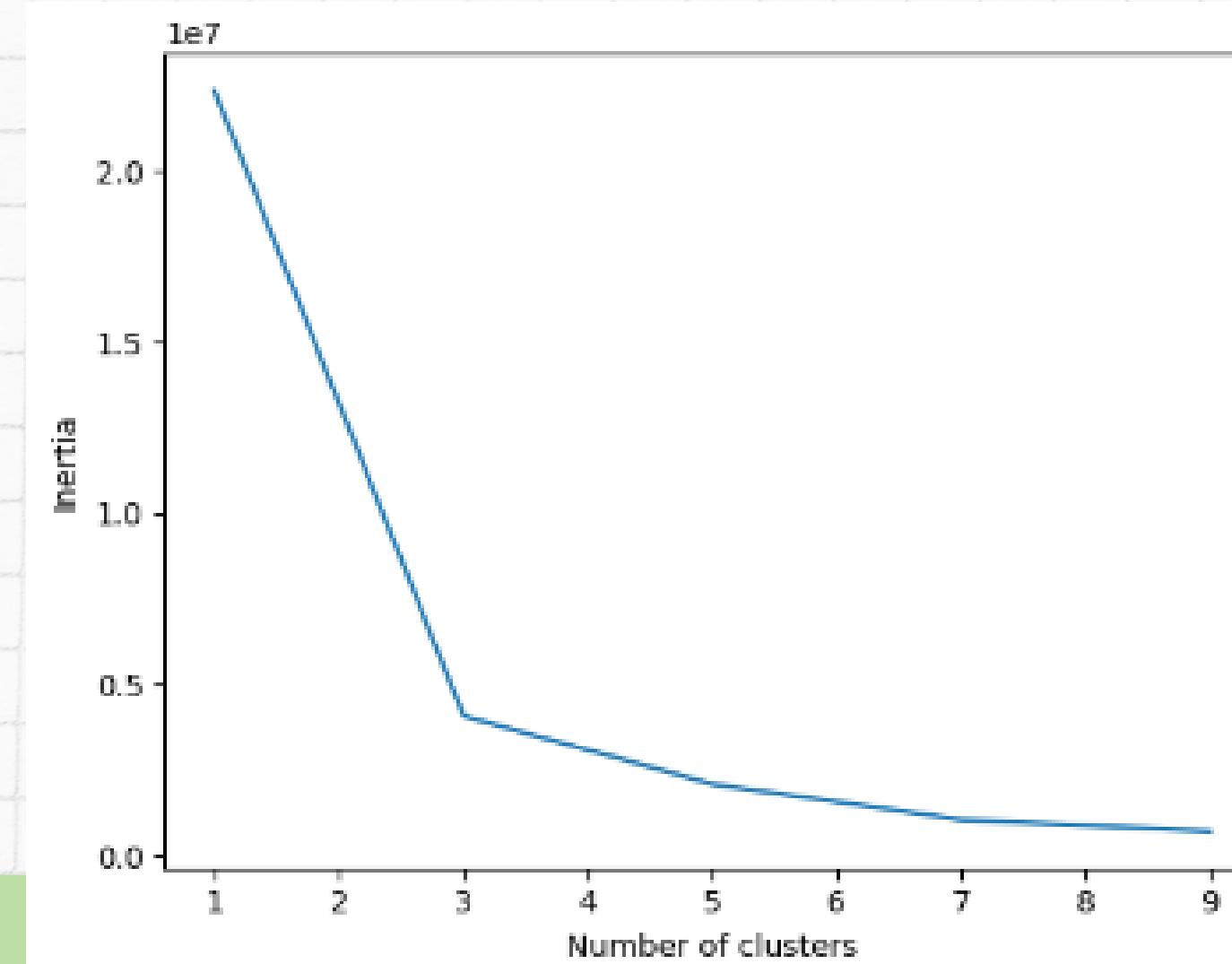


Cluster 3

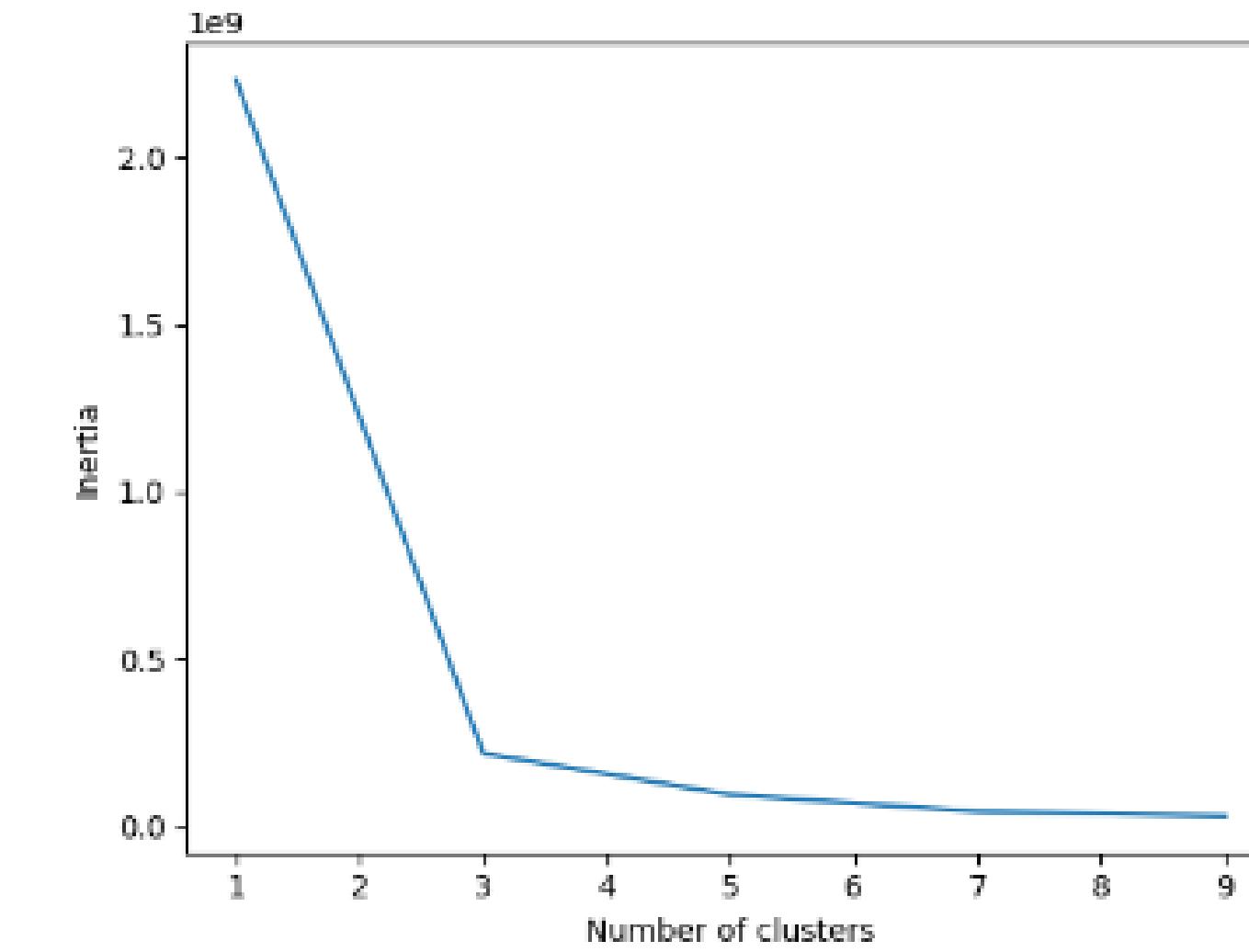
Cluster 4

KNN

- The best unsupervised clustering for small data sets.
- K = 3 for both waste generation and recycling
- Inertia: a measure of how well a dataset was clustered by K-Means. It is calculated by measuring the distance between each data point and its centroid, squaring this distance, and summing these squares across one cluster. A good model is one with low inertia AND a low number of clusters



The choosing of number of k based on the elbow method
for waste generation



The choosing of number of k based on the elbow method
for waste recycling

KNN -Waste generation

Netherlands

Luxembourg

Estonia

Finland

Austria

Czechia

Poland

France

Italy

Sweden

Belgium

Slovenia

Germany

UK

Denmark

Bulgaria

Greece

Ireland

Romania

Croatia

Malta

Lithuania

Hungary

Spain

Slovakia

Portugal

Cyprus

Latvia

KNN - Waste recycling

Sweden

Luxembourg

Estonia

Romania

Austria

Netherlands

Greece

France

Finland

Bulgaria

Poland

Malta

Germany

UK

Belgium

Denmark

Slovenia

Italy

Romania

Croatia

Malta

Lithuania

Hungary

Spain

Slovakia

Czechia

Portugal

Cyprus

Latvia

Limitations

- No clear characteristics for the KNN clusters.
- Not enough data to asses the KNN model
- Few data points
- Missing data and errors.
- Due to the freedom of the countries to choose their methods, sampling methods were used by some countries in some parts of the reporting tables.
Sampling errors were not included in the report
- Due to the freedom of the countries to choose their methods the non-sampling errors are difficult to summarize at the European level
- The factors influencing the trends are not very clear, based on Eurostats reports, it is not correlated with GDP and population size.



Further Work

- Analyse the waste data by categories eg Plastic packaging
- Combine the analysis with additional data like GDP.



**Thank
you very
much!**

