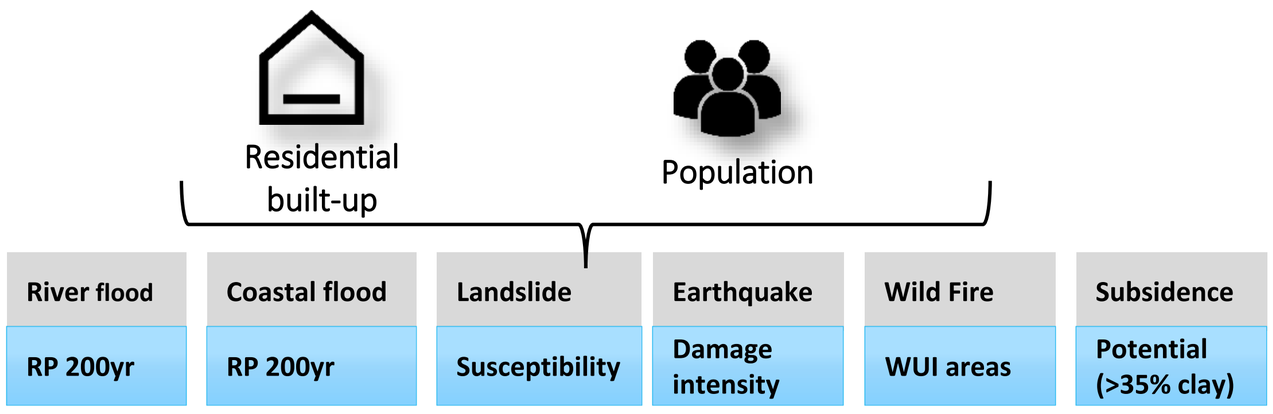
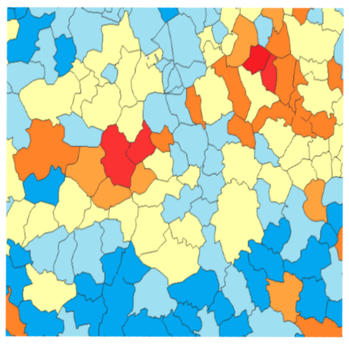
Code workflow





Population and Residential built-up EXPOSURE values per LAU as .xlsx

INPUT data

Step 1: Clustering Analysis:

INPUT data

LAU_2013.shp file (point/centroids)

1. It creates a GeoDataFrame by merging the loaded geographical data (LAU .shp file) with the data from the Excel file based on a common identifier ('LAU_ID').
2. Based on the GeoDataFrame calculates the Within Cluster Sum of Squared Errors (WCSS) for different values of K (number of nearest neighbors) using K-means clustering.
3.It finds the elbow point for the WCSS analysis, which indicates an optimal number of clusters (optimal_k).

OUTPUT:

-WCSS plots for each exposure type saved as png *(..OUTPUTS\\Plots_K_suppliment\\{column}_plot.png').*

-Optimal_k values saved to Excel files *(....\\OUTPUTS\\Plots_K_suppliment\\k_values.xlsx',).*

Step 2: Single Hazard Hotspot Analysis:

4 It builds a spatial weights matrix using a Kernel function based on the optimal_k value found in the previous step.
5. It performs hotspot analysis using Getis and Ord's G∗i statistic (G_Local).

OUTPUT:

- g_Zs and the p_sim saved in Excel files by each exposure type and by aggregation (absolute and %) for each LAU *('OUTPUTS\\Excel_Gordis_single\\{column}_result.xlsx',).*
- It groups the data frames by exposure type and by aggregation (absolute and %) for LAU *('\OUTPUTS\\Appended\\{key}_grouped.xlsx'')*

Step 3: Multi-hazard exposure by combining single hazards' exposure to multiple-hazards' exposure using Stouffer method:

6. Stouffer combined p-values and z_scores calculated for each row (LAU) from all hazards' exposures hotspots

OUTPUT:

Combined z_scores and p_values for each LAU saved to excel file by exposure type (..\OUTPUTS\\Appended\\{key}_combined.xlsx')

** _{key}. = type of exposure, Residential buildings absolute and % /Population absolute and %*

Step 4: Adding additional columns to our dataframe (combined_df):

INPUT data

NUTS3 GDP_capita.xlsx

LAU's Total population (POP_total.xlsx)

URBAN AUDIT DATA.
URAU_RG_100K_2021_3035.shp

7. **'Bin'** values based on conditions involving combined_z_scores and *p*_values
8.. **GDP per capita** values in 4 **classes** ('low income', 'low middle income', 'high middle income', 'high income') using quantiles
9. Total population for each LAU
10. Add **URAU data** (Urban Audit 2021, the Urban Audit category: with C = City and F = Functional Urban Area) to the data frame by spatial join of LAU spatial data with URAU spatial data

OUTPUT:

('OUTPUTS/Final/final_uaru_combined_dataframe_{key}.xlsx'')

** _{key}. = type of exposure, Residential buildings absolute and % /Population absolute and %*

Step 5: Figures

OUTPUT:

\OUTPUTS\\Figure\\