I. Library import

In [1]:

```
#Import the librairies
import ipywidgets as widgets
from ipywidgets import interact, interactive,HBox, VBox
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import geopandas as gpd
import geodatasets
import matplotlib.pyplot as plt
import geopandas as gpd
import pandas as pd
import folium
import matplotlib
import mapclassify
from folium.plugins import MarkerCluster
import os
```

```
c:\Users\aurel\anaconda3\Lib\site-packages\paramiko\transport.py:219: Cryptograph
yDeprecationWarning: Blowfish has been deprecated and will be removed in a future
release
  "class": algorithms.Blowfish,
```

In [2]:

```
#Read the data from 2024 and 2023 and concat them
data2 = pd.read_csv("data.csv",low_memory=False)
data1 = pd.read_csv("data2023.csv",low_memory=False)
data = pd.concat([data1, data2], ignore_index=True)
```

In [3]:

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1584106 entries, 0 to 1584105
Data columns (total 18 columns):
 #   Column                      Non-Null Count    Dtype  
---  ------                      --------------    -----  
 0   date_mutation               1584106 non-null  object 
 1   nature_mutation             1584106 non-null  object 
 2   valeur_fonciere             1584106 non-null  float64
 3   code_commune                1584106 non-null  object 
 4   code_departement            1584106 non-null  object 
 5   id_parcelle                 1584106 non-null  object 
 6   nombre_lots                 1584106 non-null  int64  
 7   code_type_local             1584106 non-null  float64
 8   nombre_pieces_principales   1584106 non-null  float64
 9   surface_terrain             1584106 non-null  float64
 10  longitude                   1584106 non-null  float64
 11  latitude                    1584106 non-null  float64
 12  tranche_valeur              1584106 non-null  object 
 13  code_insee                  1584106 non-null  int64  
 14  region_name                 1584106 non-null  object 
 15  plage_surface               1584106 non-null  object 
 16  prix_m2                     1584106 non-null  float64
 17  mois_annee                  1584106 non-null  object 
dtypes: float64(7), int64(2), object(9)
memory usage: 217.5+ MB
```

II. Création des fonctions

In [4]:

```
def selection_filters_and_analyses(df):
    # Presentation of the filters
    type_local_map = {
        1: 'House',
        2: 'Apartment',
        3: 'Dependency (Isolated)',
        4: 'Industrial and commercial premises or similar'
    }
    df['type_local'] = df['code_type_local'].map(type_local_map)

    departments = df['code_departement'].unique()
    types_properties = df['type_local'].unique()

    # Widgets for the filters
    department_select = widgets.SelectMultiple(
        options=departments,
        value=[],
        description='Departments',
        layout=widgets.Layout(width='60%')
    )
    department_select.style.description_width = '100px'

    types_properties = df['type_local'].unique()
    types_properties_select = widgets.SelectMultiple(
        options=types_properties,
        value=[],
        description='Types of property',
        layout=widgets.Layout(width='60%')
    )
    types_properties_select.style.description_width = '100px'

    price_range = ["< 50k €", "50k - 100k €", "100k - 150k €", "150k - 200k €",

    price_range_select = widgets.SelectMultiple(
        options=price_range,
        value=[],
        description='Price range',
        layout=widgets.Layout(width='60%')
    )
    price_range_select.style.description_width = '100px'

    slice_surface = ['0-50 m²', '50-100 m²', '100-150 m²', '150-200 m²', '200-25
    slice_surface_select = widgets.SelectMultiple(
        options=slice_surface,
        value=[],
        description='Surface slice',
        layout=widgets.Layout(width='60%')
    )
    slice_surface_select.style.description_width = '100px'

    # Widget to sekect the analyse to execute
    disponible_analyses = {
        "Average price per m²": show_average_price_per_m2,
        "Average surface area" : show_average_surface_per_dept,
        "Price evolution" : evolution_average_price_per_m2_per_departement_month
        "Number of main parts" :display_number_of_room_department,
        "Type of property by department" : distribution_type_property_by_departm
        "Distribution of land values" : distribution_of_land_value_by_tranche,
        "Price per m² depending on the surface area" : price_m2_per_surface,
        "Explore the map" : explore_france

    }

    analyse_select = widgets.SelectMultiple(
        options=list(disponible_analyses.keys()),
        description='Analyse',
        layout=widgets.Layout(width='60%')
    )

    analyse_select.style.description_width = '100px'

    # Button to apply the filters
    bouton_apply = widgets.Button(description="Apply the filters", button_style=

    # Function to take the filters and execute the analyse
    def apply_filter(_):
        selected_analyses = list(analyse_select.value)

        # We execute each analyse selected
        for analyse in selected_analyses:
            func = disponible_analyses[analyse]
            func(df, department_select, types_properties_select,price_range_sele

    # Link the button to the function
    bouton_apply.on_click(apply_filter)

    # Show widgets
    display(department_select, types_properties_select,price_range_select,slice_
```

In [5]:

```
def show_average_price_per_m2(df,department_select,types_properties_select,price

    # We take the department,price range, slice surface and types of properties
    selected_departments = list(department_select.value)
    selected_types_properties = list(types_properties_select.value)
    selected_price_range = list(price_range_select.value)
    selected_slice_surface = list(slice_surface_select.value)

    # If nothing is selected we take all the values for each point
    if not selected_departments:
        selected_departments = list(df['code_departement'].unique())
    if not selected_types_properties:
        selected_types_properties = list(df['type_local'].unique())
    if not selected_price_range:
        selected_price_range = ["< 50k €", "50k - 100k €", "100k - 150k €", "150
    if not selected_slice_surface:
        selected_slice_surface = ['0-50 m²', '50-100 m²', '100-150 m²', '150-200

    # Filter data based with our filter
    df_filtered = df[(df['code_departement'].isin(selected_departments)) &
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy

    df_filtered_national = df[
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy

    # Calculate the average price per m² by department
    average_price_par_dept = df_filtered.groupby('code_departement')['prix_m2'].

    # Calculate the average price of the selected departments
    average_price_select = average_price_par_dept.mean()

    # Calculate the national average price per m²
    national_average_price = df_filtered_national[df_filtered_national['type_loc

    # we create the graph
    fig, ax = plt.subplots(figsize=(20, 6))

    # We draw a bar to show the average price for each department
    ax.bar(average_price_par_dept.index, average_price_par_dept)

    # Added a bar for the average price selected
    ax.bar('Selected Average', average_price_select, alpha=0.7)

    # Added a bar for the national average price
    ax.bar('National Average', national_average_price, alpha=0.7)

    # And this is the parameters of the graphics
    ax.set_ylabel('Average price per m² (€)')
    ax.set_xlabel('Departments')
    ax.set_title("Average price per m² per department, selected and glogal avera
    ax.grid(True, linestyle='--', alpha=0.6)
    plt.xticks(rotation=90)
    plt.tight_layout()  # To avoid labels overlapping
    plt.show()
```

In [6]:

```
def show_average_surface_per_dept(df,department_select,types_properties_select,p

    # We take the department,price range, slice surface and types of properties
    selected_departments = list(department_select.value)
    selected_types_properties = list(types_properties_select.value)
    selected_price_range = list(price_range_select.value)
    selected_slice_surface = list(slice_surface_select.value)

    # If nothing is selected we take all the values for each point
    if not selected_departments:
        selected_departments = list(df['code_departement'].unique())
    if not selected_types_properties:
        selected_types_properties = list(df['type_local'].unique())
    if not selected_price_range:
        selected_price_range = ["< 50k €", "50k - 100k €", "100k - 150k €", "150
    if not selected_slice_surface:
        selected_slice_surface = ['0-50 m²', '50-100 m²', '100-150 m²', '150-200

    # Filter data based with our filter
    df_filtered = df[(df['code_departement'].isin(selected_departments)) &
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy

    df_filtered_national = df[
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy


    # We calculate the average surface area for each selected department
    average_area_par_dept = df_filtered.groupby('code_departement')['surface_ter

    # Calculate the average surface area of the selected departments
    surface_moyenne_selectionnee = average_area_par_dept.mean()

    # Calculate the national average surface area (average of all selected depar
    national_average_area = df_filtered_national[df_filtered_national['type_loca

    fig, ax = plt.subplots(figsize=(20, 6))

    # We plot the average area for each selected department
    ax.bar(average_area_par_dept.index, average_area_par_dept, label='Average Su

    # Add a bar for the average area of the selected departments
    ax.bar('Selected Average', surface_moyenne_selectionnee, label='Selected Ave

    # Add a bar for the national average area
    ax.bar('National average', national_average_area, label='National average', 

    # parameters of the graphics
    ax.set_ylabel('Average surface area in m²')
    ax.set_xlabel('Departments')
    ax.set_title("Average surface area in m² by department, selection and global
    ax.grid(True, linestyle='--', alpha=0.6)
    ax.legend(title="Legend", bbox_to_anchor=(1.05, 1), loc='upper left')
    plt.xticks(rotation=90)
    plt.tight_layout()
    plt.show()
```

In [7]:

```
def evolution_average_price_per_m2_per_departement_monthly(df,department_select,
    # We take the department,price range, slice surface and types of properties
    selected_departments = list(department_select.value)
    selected_types_properties = list(types_properties_select.value)
    selected_price_range = list(price_range_select.value)
    selected_slice_surface = list(slice_surface_select.value)

    # If nothing is selected we take all the values for each point
    if not selected_departments:
        selected_departments = list(df['code_departement'].unique())
    if not selected_types_properties:
        selected_types_properties = list(df['type_local'].unique())
    if not selected_price_range:
        selected_price_range = ["< 50k €", "50k - 100k €", "100k - 150k €", "150
    if not selected_slice_surface:
        selected_slice_surface = ['0-50 m²', '50-100 m²', '100-150 m²', '150-200

   # Filter data based with our filter
    df_filtered = df[(df['code_departement'].isin(selected_departments)) &
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy

    df_filtered_national = df[
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy

    # we verify that the date column is in the correct format
    df_filtered['date_mutation'] = pd.to_datetime(df_filtered['date_mutation'])

    # we take the average price per department for each month
    average_price_par_dept_mois = df_filtered.groupby(['code_departement', 'mois


    plt.figure(figsize=(15, 8))

    # Add the curve for the global average
    df_dept_global = df_filtered.groupby('mois_annee')['prix_m2'].mean().reset_i
    plt.plot(df_dept_global['mois_annee'].astype(str), df_dept_global['prix_m2']

    # Add the curve for the national average (based on the entire data)
    df_national_global = df_filtered_national.groupby('mois_annee')['prix_m2'].m
    plt.plot(df_national_global['mois_annee'].astype(str), df_national_global['p

    # Add the curves for each selected department
    for departement in selected_departments:
        df_dept = average_price_par_dept_mois[average_price_par_dept_mois['code_
        plt.plot(df_dept['mois_annee'].astype(str), df_dept['prix_m2'], marker='

    plt.title("Evolution of the average price per m² by department (monthly)")
    plt.xlabel("Month and year")
    plt.ylabel("Average price per m² (€)")
    plt.legend(title="Types of property", bbox_to_anchor=(1.05, 1), loc='upper l
    plt.grid(True, linestyle='--', alpha=0.6)
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()
```

In [8]:

```
def display_number_of_room_department(df,department_select,types_properties_sele
    # We take the department,price range, slice surface and types of properties
    selected_departments = list(department_select.value)
    selected_types_properties = list(types_properties_select.value)
    selected_price_range = list(price_range_select.value)
    selected_slice_surface = list(slice_surface_select.value)

    # If nothing is selected we take all the values for each point
    if not selected_departments:
        selected_departments = list(df['code_departement'].unique())
    if not selected_types_properties:
        selected_types_properties = list(df['type_local'].unique())
    if not selected_price_range:
        selected_price_range = ["< 50k €", "50k - 100k €", "100k - 150k €", "150
    if not selected_slice_surface:
        selected_slice_surface = ['0-50 m²', '50-100 m²', '100-150 m²', '150-200

     # Filter data based with our filter
    df_filtered = df[(df['code_departement'].isin(selected_departments)) &
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy

    df_filtered_national = df[
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy


    # We take the number of main room per department
    number_piece_per_dept = df_filtered.groupby('code_departement')['nombre_piec

    # Ajouter la moyenne générale des départements sélectionnés
    average_selection = df_filtered['nombre_pieces_principales'].mean()
    national_average = df_filtered_national['nombre_pieces_principales'].mean()

    # Ajouter une barre pour la moyenne générale
    departments = list(number_piece_per_dept['code_departement'])
    number_room = list(number_piece_per_dept['nombre_pieces_principales'])

    plt.figure(figsize=(15, 8))
    plt.bar(departments, number_room, color='skyblue')
    #We plot line for average and national average of main rooms
    plt.axhline(average_selection, color='red', linestyle='dashed', linewidth=2,
    plt.axhline(national_average, color='green', linestyle='dashed', linewidth=2

    plt.title("Average number of rooms per department and per type of property s
    plt.xlabel("Department")
    plt.ylabel("Average number of rooms")
    plt.xticks(rotation=90)
    plt.legend()
    plt.grid(True, linestyle='--', alpha=0.6)
    plt.tight_layout()
    plt.show()
```

In [9]:

```
def distribution_type_property_by_department(df,department_select,types_properti
    # We take the department,price range, slice surface and types of properties
    selected_departments = list(department_select.value)
    selected_types_properties = list(types_properties_select.value)
    selected_price_range = list(price_range_select.value)
    selected_slice_surface = list(slice_surface_select.value)

   # If nothing is selected we take all the values for each point
    if not selected_departments:
        selected_departments = list(df['code_departement'].unique())
    if not selected_types_properties:
        selected_types_properties = list(df['type_local'].unique())
    if not selected_price_range:
        selected_price_range = list(df['tranche_valeur'].unique())
    if not selected_slice_surface:
        selected_slice_surface = list(df['plage_surface'].unique())

     # Filter data based with our filter
    df_filtered = df[(df['code_departement'].isin(selected_departments)) &
                     (df['type_local'].isin(selected_types_properties))&
                     (df['tranche_valeur'].isin(selected_price_range))&
                     (df['plage_surface'].isin(selected_slice_surface))].copy

    # Calculate the distribution of property types by department
    distribution = df_filtered.groupby(['code_departement', 'type_local']).size(

    # Normalize to obtain proportions (in %)
    distribution_norm = distribution.div(distribution.sum(axis=1), axis=0) * 100

    # creating a Stacked Bar Chart
    distribution_norm.plot(kind='bar', figsize=(15, 8), stacked=True, colormap='

    plt.title("Distribution of transactions by type of property and by departmen
    plt.xlabel("Department")
    plt.ylabel("Proportion of transactions (%)")
    plt.legend(title="Types of properties", bbox_to_anchor=(1.05, 1), loc='upper
    plt.grid(axis='y', linestyle='--', alpha=0.6)
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()
```

In [19]:

```
def distribution_of_land_value_by_tranche(df, department_select, types_propertie
    # Ordered list of price ranges
    price_order = [
        "< 50k €", "50k - 100k €", "100k - 150k €", "150k - 200k €", "200k - 250
        "250k - 300k €", "300k - 350k €", "350k - 400k €", "400k - 450k €", "450
        "500k - 550k €", "550k - 600k €", "600k - 650k €", "650k - 700k €", "700
        "750k - 800k €", "800k - 850k €", "850k - 900k €", "900k - 950k €", "950
        "1M - 1.5M €", "1.5M - 2M €", "2M - 2.5M €", "2.5M - 3M €", "3M - 4M €",
    ]

    # Transform the 'tranche_valeur' column into an ordered category
    df['tranche_valeur'] = pd.Categorical(df['tranche_valeur'], categories=price

    # Selections
    selected_departments = list(department_select.value)
    selected_types_properties = list(types_properties_select.value)
    selected_price_range = list(price_range_select.value)
    selected_slice_surface = list(slice_surface_select.value)

    # Default to all if no selections
    if not selected_departments:
        selected_departments = list(df['code_departement'].unique())
    if not selected_types_properties:
        selected_types_properties = list(df['type_local'].unique())
    if not selected_price_range:
        selected_price_range = price_order
    if not selected_slice_surface:
        selected_slice_surface = ['0-50 m²', '50-100 m²', '100-150 m²', '150-200
                                  '250-300 m²', '300-350 m²', '350-400 m²', '400
                                  '500-600 m²', '600-700 m²', '700-800 m²', '800

    # Filter data
    df_filtered = df[(df['code_departement'].isin(selected_departments)) &
                     (df['type_local'].isin(selected_types_properties)) &
                     (df['tranche_valeur'].isin(selected_price_range)) &
                     (df['plage_surface'].isin(selected_slice_surface))].copy()

    # Count the number of transactions by tranche and by department
    distribution = df_filtered.groupby(['tranche_valeur', 'code_departement']).s

    # Calculate percentages relative to each department's total
    distribution_percentage = distribution.div(distribution.sum(axis=0), axis=1)

    # Plot side-by-side bar chart
    ax = distribution_percentage.plot(kind='bar', figsize=(15, 8), width=0.8, cc

    # Update plot settings
    plt.title("Distribution of transactions by land value range and by departmen
    plt.xlabel("Land value range (€)")
    plt.ylabel("Percentage of transactions (%)")
    plt.legend(title="Department", bbox_to_anchor=(1.05, 1), loc='upper left')
    plt.grid(axis='y', linestyle='--', alpha=0.6)
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()
```

In [11]:

```
def price_m2_per_surface(df, department_select, types_properties_select,price_ra
    # We take the department,price range, slice surface and types of properties
    selected_departments = list(department_select.value)
    selected_types_properties = list(types_properties_select.value)
    selected_price_range = list(price_range_select.value)
    selected_slice_surface = list(slice_surface_select.value)

    # If nothing is selected we take all the values for each point
    if not selected_departments:
        selected_departments = list(df['code_departement'].unique())
    if not selected_types_properties:
        selected_types_properties = list(df['type_local'].unique())
    if not selected_price_range:
        selected_price_range = ["< 50k €", "50k - 100k €", "100k - 150k €", "150
    if not selected_slice_surface:
        selected_slice_surface = ['0-50 m²', '50-100 m²', '100-150 m²', '150-200

     # Filter data based with our filter
    df_filtered = df[(df['code_departement'].isin(selected_departments)) &
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy

    df_filtered_national = df[
                        (df['type_local'].isin(selected_types_properties))&
                        (df['tranche_valeur'].isin(selected_price_range))&
                        (df['plage_surface'].isin(selected_slice_surface))].copy

    # Calculate the average price by surface area and department
    average_price_per_surface = df_filtered.groupby(['plage_surface', 'code_depa

     # Calculate average by surface range for selection
    average_selection = df_filtered.groupby('plage_surface')['prix_m2'].mean().r

    # Calculate the national average by surface area
    national_average = df_filtered_national.groupby('plage_surface')['prix_m2'].

    # Creating the graph
    plt.figure(figsize=(12, 8))
    #For each department selected, we take the average price per suface and then
    for department in selected_departments:
        df_department = average_price_per_surface[average_price_per_surface['cod
        if not df_department.empty:
            plt.plot(
                df_department['plage_surface'],
                df_department['prix_m2'],
                marker='o',
                label=f'Department {department}'
            )
    plt.plot(
        average_selection['plage_surface'],
        average_selection['prix_m2'],
        marker='o',
        linestyle='--',
        label='Selected average',
        color='black'
    )
    # Then we add the National average line
    plt.plot(
        national_average['plage_surface'],
        national_average['prix_m2'],
        marker='o',
        linestyle=':',
        label='National average',
        color='red'
    )

    # graph configurations
    plt.title("Average price per m² depending on surface area ranges")
    plt.xlabel("Surface range (m²)")
    plt.ylabel("Average price per m² (€)")
    plt.legend(title="Departement", bbox_to_anchor=(1.05, 1), loc='upper left')
    plt.grid(True, linestyle='--', alpha=0.6)
    plt.xticks(rotation=45)
    plt.tight_layout()
    plt.show()
```

In [12]:

```
def add_region_name_column(df):
    """
    Add a column 'region_name' to the dataframe with the name of the region corr

    :param df: DataFrame with the column 'code_insee' containing the INSEE codes

    :return: DataFrame with the added column 'region_name'
    """
    # Dictionary of INSEE codes for regions and their names
    regions_names = {
        "01": "Guadeloupe", "02": "Martinique", "03": "Guyane", "04": "La Réunic
        "24": "Centre-Val de Loire", "27": "Bourgogne-Franche-Comté", "28": "Nor
        "44": "Grand Est", "52": "Pays de la Loire", "53": "Bretagne", "75": "Nc
        "84": "Auvergne-Rhône-Alpes", "93": "Provence-Alpes-Côte d'Azur", "94":
    }
    df['region_name'] = df['code_insee'].map(regions_names)
    return df
```

In [13]:

```
def explore_france(data, department_select=None, types_properties_select=None, p
    """
    Displays a map of France with the average price per m² of land by region, an

    Parameters:
    - data : pd.DataFrame : The DataFrame containing the data of real estate tra
    - department_select : ipywidgets.SelectMultiple : The widget for selecting d
    - types_properties_select : ipywidgets.SelectMultiple : The widget for selec
    - price_range_select : ipywidgets.SelectMultiple : The widget for selecting
    - slice_surface_select : ipywidgets.SelectMultiple : The widget for selectin

    Returns:
    - Map of France with the average price per m² of land by region, and the loc

    """
    data_general = data.copy()

    #We take the department,price range, slice surface and types of properties s
    selected_departments = list(department_select.value)
    selected_types_properties = list(types_properties_select.value)
    selected_price_range = list(price_range_select.value)
    selected_slice_surface = list(slice_surface_select.value)
    # If nothing is selected we take all the values for each point
    if not selected_departments:
        selected_departments = list(data['code_departement'].unique())
    if not selected_types_properties:
        selected_types_properties = list(data['type_local'].unique())
    if not selected_price_range:
        selected_price_range = ["< 50k €", "50k - 100k €", "100k - 150k €", "150
    if not selected_slice_surface:
        selected_slice_surface = ['0-50 m²', '50-100 m²', '100-150 m²', '150-200

    # Filter data based with our filter
    data = data[
        (data['code_departement'].isin(selected_departments)) &
        (data['type_local'].isin(selected_types_properties)) &
        (data['tranche_valeur'].isin(selected_price_range)) &
        (data['plage_surface'].isin(selected_slice_surface))
    ].copy()

    # Load shapefile
    shp_file_path = "regions.shx"
    map_france = gpd.read_file(shp_file_path)

    # Define the CRS
    if map_france.crs is None:
        map_france = map_france.set_crs(epsg=4326, allow_override=True)

    #We verify that the column 'code_insee' is in the correct format and correct
    data_general["code_insee"] = data_general["code_insee"].astype(str).str.zfil

    #Average price per m² by region
    ratio_average = data_general.groupby('code_insee')['prix_m2'].mean()

    # Add the average land value by region stylized in euros
    map_france['Average_land_value'] = map_france['code_insee'].map(ratio_averag
    map_france['Average_land_value'] = map_france['Average_land_value'].apply(la


    # Normalize the values
    ratio_average = (ratio_average - ratio_average.min()) / (ratio_average.max()

    # Logarithmic transformation to accentuate differences
    ratio_average = np.log1p(ratio_average * 10)

    map_france = map_france.set_index('code_insee').join(ratio_average, how='lef
    map_france = add_region_name_column(map_france)

    sample_data = data.copy() if department_select and types_properties_select a

    geometry = gpd.GeoSeries.from_xy(sample_data['longitude'], sample_data['lati
    points_gdf = gpd.GeoDataFrame(sample_data, geometry=geometry)

    # Creating the map
    map = folium.Map(location=[46.603354, 1.888334], zoom_start=6)
    map_france["prix_m2"].fillna(0, inplace=True)
    # We add the regions to the map
    folium.GeoJson(
        map_france,
        name='geojson',
        style_function=lambda feature: {
            'fillColor':  matplotlib.colors.rgb2hex(plt.cm.plasma(feature['prope
            'color': matplotlib.colors.rgb2hex(plt.cm.plasma(feature['properties
            'weight': 2,
            'fillOpacity': 0.5,
        },
        tooltip=folium.GeoJsonTooltip(fields=['region_name', 'Average_land_value

    ).add_to(map)

    # Add some points
    marker_cluster = MarkerCluster().add_to(map)
    #We added popup to each properties to display information about the property
    for idx, row in points_gdf.iterrows():
        folium.Marker(
            location=[row['latitude'], row['longitude']],
            popup=f"{row.get('region_name', 'N/A')} \n Type : {row.get('type_loc
            icon=folium.Icon(color='red', icon='home')
        ).add_to(marker_cluster)

    display(map)
    return map
```

III. Exécution des fonctions

Investor profile

1. Situation of the investor:

The investor is a family looking for a 5-person home with a large number of rooms. They need living space between 250 m2 and 400 m2 because they have children which have between 10 and 15 years old.

2. Goal of the investment:

Type of property sought: House preferably but they could go for an apartment if they have a crush. Prime location: In Auvergne Rhône-Alpes close to Lyon (2h maximum because they have family there) (departments 69,38,01,42). Budget : between 400k€ and 550k€ maximum. Priority: at least 4 rooms, This is a family who often change of houses (every 2 or 3 years) so they don't want to buy a property which lost too much values with the time.

3. Constraints and secondary criteria :

They don't want to be in the city directly, They want to be on the outskirts of town, with potentially shops and a college nearby.

4. Investment strategy :

Looking for an excellent price/m2 ratio. they do not want to carry out work on their property even if it means paying more.

5. Economic context :

This purchase is motivated by a short-term family need. The investor is attentive to the evolution of real estate prices in the targeted areas, so he could go for a property outside Lyon (up to 2 hours).

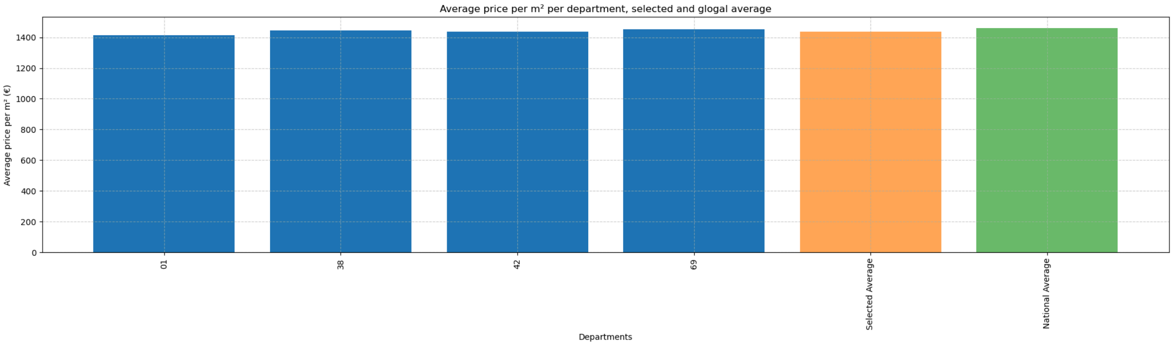
Summary of key expectations :

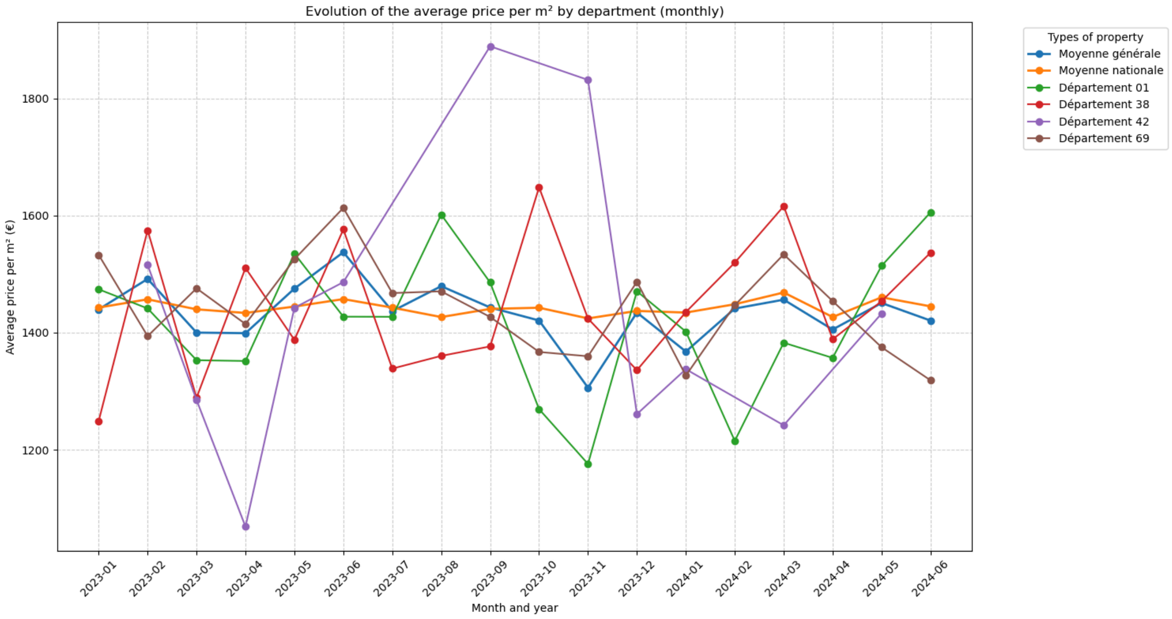
property: Houses or appartment. Surface : between 250 m2 and 400 m2. departments: 69,01,42,38. Budget : between 400K€ and 550 K€. Priorité : close to Lyon but can be at 2h max for the family.At least 4 rooms, don't want to be in the city directly,an excellent price/m2 ratio.

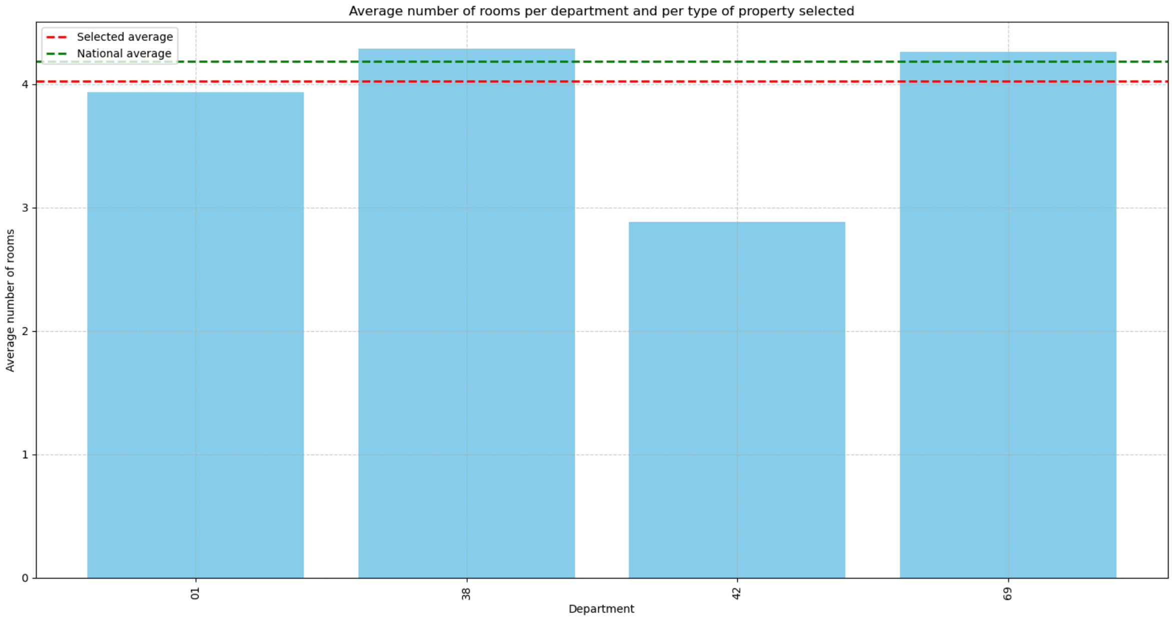
(I put the analysis of the graph under the display of the graph)

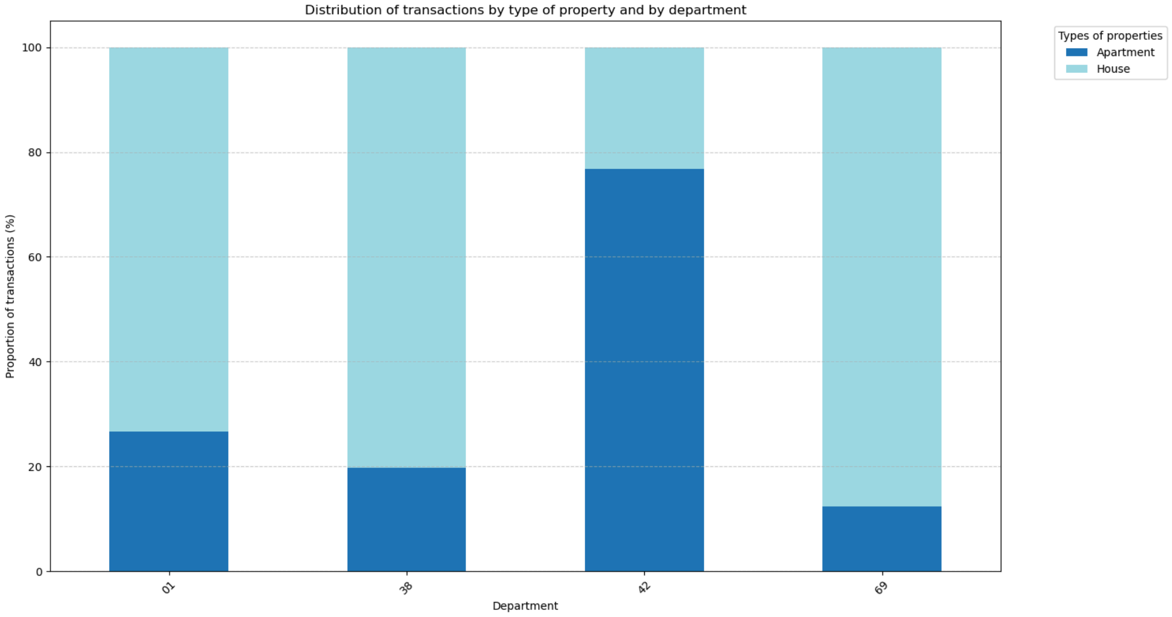
```
In [21]: selection_filters_and_analyses(data)
```

```
SelectMultiple(description='Departments', layout=Layout(width='60%'), options=('0
1', '02', '03', '04', '05', '…
SelectMultiple(description='Types of property', layout=Layout(width='60%'), optio
ns=('House', 'Dependency (Iso…
SelectMultiple(description='Price range', layout=Layout(width='60%'), options=('<
50k €', '50k - 100k €', '100…
SelectMultiple(description='Surface slice', layout=Layout(width='60%'), options=
('0-50 m²', '50-100 m²', '100-…
SelectMultiple(description='Analyse', layout=Layout(width='60%'), options=('Avera
ge price per m²', 'Average su…
Button(button_style='success', description='Apply the filters', style=ButtonStyle
())
```

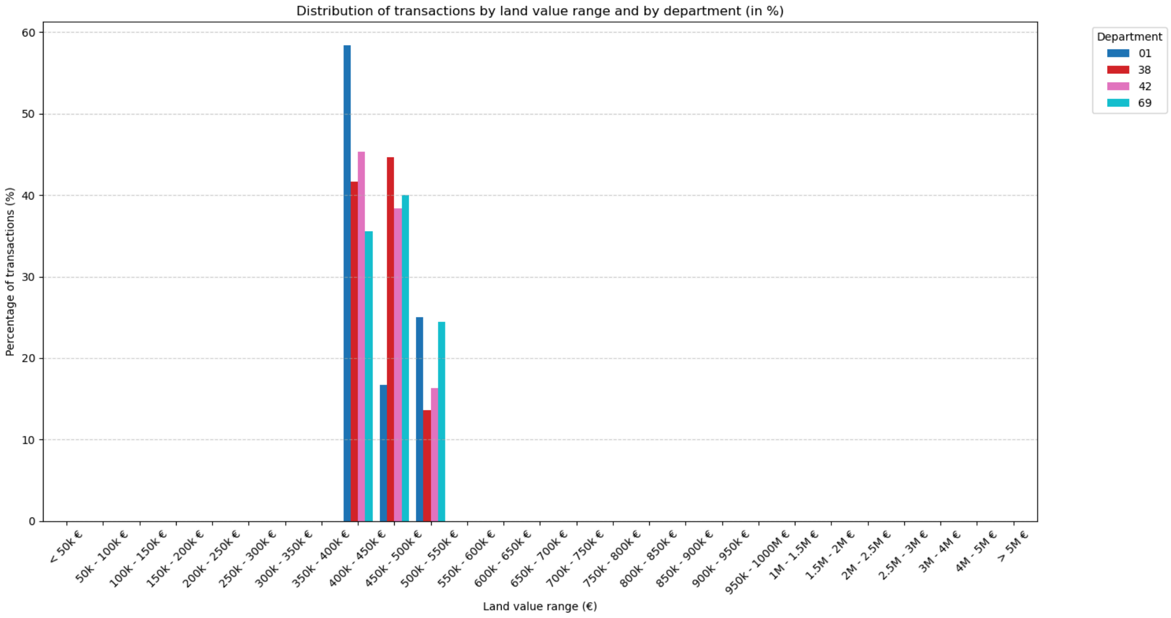








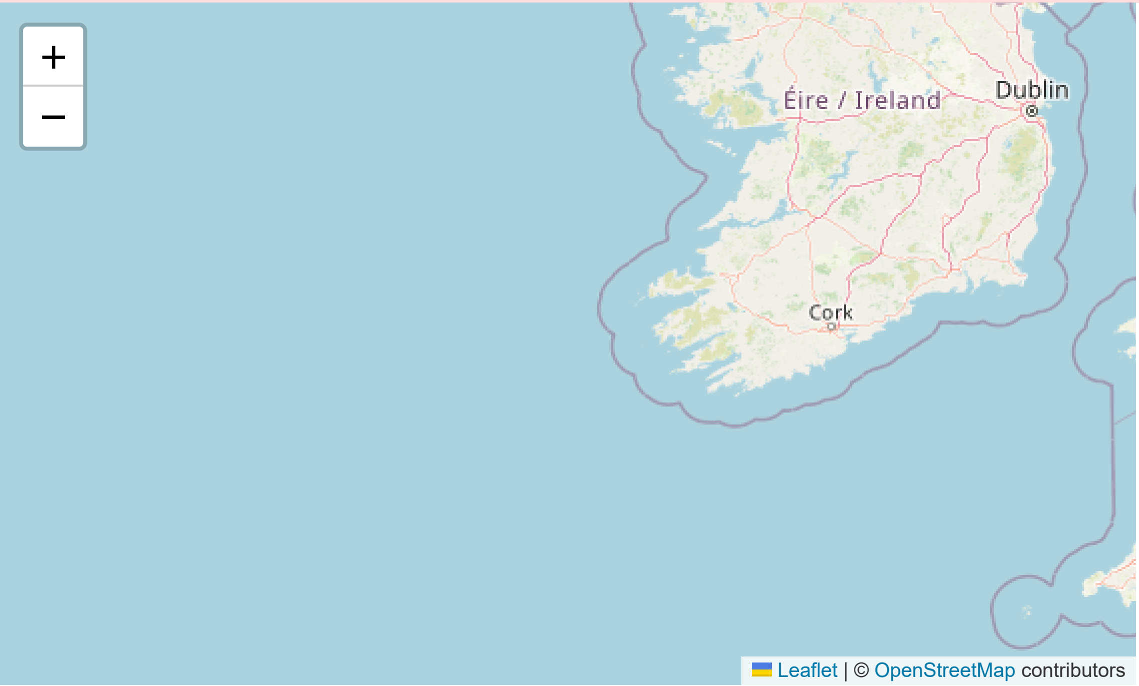
```
C:\Users\aurel\AppData\Local\Temp\ipykernel_13564\1362677495.py:39: FutureWarning: The default of observed=False is deprecated and will be changed to True in a future version of pandas. Pass observed=False to retain current behavior or observed=True to adopt the future default and silence this warning.
  distribution = df_filtered.groupby(['tranche_valeur', 'code_departement']).size().unstack(fill_value=0)
```



```
C:\Users\aurel\AppData\Local\Temp\ipykernel_13564\97304001.py:76: FutureWarning:
A value is trying to be set on a copy of a DataFrame or Series through chained as
signment using an inplace method.
The behavior will change in pandas 3.0. This inplace method will never work becau
se the intermediate object on which we are setting values always behaves as a cop
y.

For example, when doing 'df[col].method(value, inplace=True)', try using 'df.meth
od({col: value}, inplace=True)' or df[col] = df[col].method(value) instead, to pe
rform the operation inplace on the original object.


  map_france["prix_m2"].fillna(0, inplace=True)
```



In the first bar plot, which display in the X axis the department and in the Y axis the average price per m2, and one of the criteria of our client was the ratio price per meter square. So on this graphics, we can see that all the average price of each region seems to be quite similar and they are also very similar to the National average. So we can't make a conclusion on which department that can be interested directly with this case.

The second graph represent the evolution of the average price per m2 which is very important for these user because he might rechange his proporty in 2 or 3 years so the price should not goes down. To take the less risk as possible we need to check the department with the lowest evolution of price in the last year and a half. And we can see that the 38 and 69 seems to be the best for this evaluation. The department 42 is not a good deal at all for this family because he has a big variation of his prices.

Then the third graph which represent the average number of room per properties and per department, and we can see that the 38 and 69 department seems hae the hightest number of room in general and this can be interesting for our family which research a property with at least 4 rooms. And the department 42 seems not be a good place to search for this family with less than 3 room in average.

Then We can see the distribution of type of property per department which allow the user to see if there is more apartment or houses which have transaction in a department. To remind, our family wants to buy a house in priority and they can bought an appartment only if they have a crush on. So we can see that the department 42 has in majority appartment transactions so we can eliminate him. The we can see that the 69 department which is close to lyon (another criteria from the family), has the lowest percentage of appartment transaction.

The fifth graphics is representing the distribution of transaction by land value range and by department. So on the range of value that the family asked, we can see that the department 01,38 and 42 have transaction on the lowest range of the given budget of the family. For the 69 department, we can see that the transaction seems more balance on the three range of land value so it can allows to the family to discover a best range of properties but they might paid more for their houses.

Then the final graph is a map which display all the properties which are containing in our filters. In this map we can see each properties with his own type of property, price and surface. So we can use it to see where they are situated and also if the price and the surface might be interesting in a city for example. In our example the department 69 might be a good idea for our family so she can look at the houses in the outskirts of the town (Lyon).

To conclude, all this graphs can help the user to gave him an idea of the best department or if his research is going in the right direction. In our case the 69 department might me a good solution but the 38 can also be very interesting for this family.